AFRL-RX-TY-TR-2009-4585

MINE AREA CLEARANCE VEHICLE (MACV) (HYDREMA FLAIL SYSTEM) REMOTE OPERATOR GUIDE

Marshall G. Dutton

Applied Research Associates
P.O. Box 40128
Tyndall AFB, FL 32403

NOVEMBER 2005

AIRBASE TECHNOLOGIES DIVISION
MATERIALS AND MANUFACTURING DIRECTORATE
AIR FORCE RESEARCH LABORATORY
AIR FORCE MATERIEL COMMAND
139 BARNES DRIVE, SUITE 2
TYNDALL AIR FORCE BASE, FL 32403-5323

NOTICE AND SIGNATURE PAGE

Using Government drawings, specifications, or other data included in this document for any purpose other than Government procurement does not in any way obligate the U.S. Government. The fact that the Government formulated or supplied the drawings, specifications, or other data does not license the holder or any other person or corporation; or convey any rights or permission to manufacture, use, or sell any patented invention that may relate to them.

This report was cleared for public release by the Air Force Research Laboratory, Materials and Manufacturing Directorate, Airbase Technologies Division, Public Affairs and is available to the general public, including foreign nationals. Copies may be obtained from the Defense Technical Information Center (DTIC) (http://www.dtic.mil).

REPORT NUMBER AFRL-RX-TY-TR-2009-4585 HAS BEEN REVIEWED AND IS APPROVED FOR PUBLICATION IN ACCORDANCE WITH ASSIGNED DISTRIBUTION STATEMENT.

//signature//
WALTER M. WALTZ
Work Unit Manager

//signature//
JOHN S. MASCELLI, Captain, USAF
Acting Chief, Force Protection Branch

//signature//
ALBERT N. RHODES, PhD
Acting Chief, Airbase Technologies Division

This report is published in the interest of scientific and technical information exchange, and its publication does not constitute the Government's approval or disapproval of its ideas or findings.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
04-NOV-2005	Interim Technical Report	04-NOV-2005 -- 04-NOV-2005

4. TITLE AND SUBTITLE

Mine Area Clearance Vehicle (MACV) (Hydrema Flail System) Remote Operator Guide

5a. CONTRACT NUMBER

FA4819-07-D-0001

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

99999F

6. AUTHOR(S)

Dutton, Marshall G.

5d. PROJECT NUMBER

MACE

5e. TASK NUMBER

F0

5f. WORK UNIT NUMBER

OAFT0202

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Applied Research Associates
P.O. Box 40128
Tyndall Air Force Base, FL 32403

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Air Force Research Laboratory
Materials and Manufacturing Directorate
Airbase Technologies Division
139 Barnes Drive, Suite 2
Tyndall Air Force Base, FL 32403-5323

10. SPONSOR/MONITOR'S ACRONYM(S)

AFRL/RXQF

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

AFRL-RX-TY-TR-2009-4585

12. DISTRIBUTION/AVAILABILITY STATEMENT

Distribution Statement A: Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES

Ref AFRL/RXQ Public Affairs Case # 09-193. Document contains color images.

14. ABSTRACT

This Operators Guide contains procedures for the remote operation of the Mine Area Clearance Vehicle (MACV) or Hydrema Flail System. The procedures outlined in this guide are in addition to the standard operating procedures outlined in the Hydrema Vehicle Operators Manual and all operational and safety procedures specified in the Operators Manual must be strictly followed if not specifically superseded by this guide.

15. SUBJECT TERMS

MACV, MACE, mine clearance, flail, teleremote, Hydrema, sensors, robotic, ACC, E-Stop, operator, OCU, watchdog, joystick, console, procedures, laptop, GPS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Walter M. Waltz
U	U	U	UU	63	19b. TELEPHONE NUMBER *(Include area code)*

Reset

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

MINE AREA CLEARANCE VEHICLE (MACV)
(HYDREMA FLAIL SYSTEM)

REMOTE OPERATORS GUIDE

4 NOVEMBER 2005

AIR FORCE RESEARCH LABORATORY
ROBOTICS RESEARCH TEAM
TYNDALL AIR FORCE BASE
TYNDALL AFB, FL 32403
DSN 523-3725; COMM (850) 283-3725

General: This Operators Guide contains procedures for the remote operation of the Mine Area Clearance Vehicle (MACV) or Hydrema Flail System. The procedures outlined in this guide are in addition to the standard operating procedures outlined in the Hydrema Vehicle Operators Manual and all operational and safety procedures specified in the Operators Manual must be strictly followed if not specifically superseded by this guide.

The Hydrema vehicle can also be operated manually when both vehicle mounted E-STOPs are OFF (OUT) position and the Bumper Console switches are positioned as follows:

- Place Remote – Manual Switch to the Manual position
- Place Safe – Enable Switch in the Enable position

The information contained within this Operators Guide has been divided into sections that apply to the activities associated with the remote operation of the Hydrema Flail System. Sections contained within this guide follow:

WARNINGS: **By definition, a WARNING means that a dangerous situation may occur if no necessary precautions are taken. The Operator's Manual for the Hydrema vehicle contains a complete listing of all WARNINGS applicable to manual operation of the vehicle. With the integration of a remote control system that enable unmanned vehicle operations, the following additional WARNINGS are required to ensure safe vehicle operations:**

When the strobe light on the vehicle is flashing, the vehicle is capable of remote operations.
Rationale: The flashing strobe light provides a visual signal to any person in the vicinity of the operating area that the vehicle is being remotely operated and all personnel should stay clear of the vehicle. The vehicle operator is located at a remote site (away from the vehicle) and is using a Joystick Control Box to control the vehicle which means the vehicle operator cannot always "see" personnel in close proximity to the vehicle.

When the vehicle engine is running and the vehicle is not flailing, stay at least 50 feet from the vehicle.
Rationale: With the vehicle engine running, the remotely controlled vehicle is capable of forward or rearward movement at any time. Personnel are warned to stand clear of the vehicle by at least 50 feet.

When flailing operations are in progress, stay at least 600 feet from the vehicle.
Rationale: As the rotating flail encounters and demolishes items in its path, there is always the possibility that debris items may be hurled great distances. **When flailing against live ordnance items, distances greater than 600 feet may be required.** Safe standoff distances for specific types of ordnance should be consulted and taken to ensure the safety of the operator.

Before performing any maintenance or troubleshooting procedures on the remote system, ensure engines are off, the SAFETY SWITCH is in the SAFE position, and the flail and shield are either stowed and locked or are resting on the ground.
Rationale: These procedures insure the vehicle and/or vehicle components cannot be moved or remotely operated while maintenance or troubleshooting procedures are being performed.

Ensure the 115VAC power source is 60Hz, using other than 60Hz may damage or cause the system to not operate properly.

Once power has been applied to the COM/GPS system, do not unplug any of the cables. Power down the system by placing the Power Switch to the off position (down) prior to unplugging any cable connections. Doing so may cause the system to be reset to the factory defaults rendering the remote system non-operational.

Operational Safety

Hydrema MACV Safety

To ensure safe operation, the Hydrema employs two levels of safety, the Vehicle level and the OCU level.

On the Vehicle level, the bumper control console houses two switches, two LEDs, a strobe light, and an E-Stop button. The remote switch is the Manual-Remote switch. This is the main switch since it powers up all the vehicle remote electronics. *This switch shall always be on Manual when the vehicle is not under remote operation*. The safety switch is the Safe-Enable switch. *When working around the vehicle, the switch shall always be on Safe*. However, for the vehicle states as seen on the OCU to take effect, the bumper switch must be on Enable.

The Light Emitting Diodes (LED) on the bumper are indicators for remote operation. The Heartbeat LED reflects the vehicle health. Normally, the Heartbeat LED blinks once every two seconds. The Heartbeat LED stops blinking if the vehicle goes into an error state. The Communication LED reflects the communication link between the vehicle computer and the OCU. Under normal conditions, the Communication LED flashes twice every second. The other blinking states are described in the chart below. The LED stops blinking when the communication link is compromised or lost completely. The strobe light flashes when the OCU has control of the vehicle. Finally, the E-Stop button kills the engine and locks out control of the vehicle. *The E-Stop button must be activated when performing close-up inspection or servicing of the vehicle.*

On the OCU level, the Hydrema uses Watchdogs to indicate error conditions. A *Watchdog* is an internal computer program that monitors specific states of the system and indicates error conditions, and acts on them accordingly.

Table 1 enumerates all the watchdogs that may appear on the OCU. The leftmost column shows what type of watchdog occurs and how it is displayed on the OCU. The second column describes the possible causes. The third column illustrates the responses on both the vehicle and the OCU. The fourth column enumerates the operator actions to troubleshoot the error based on the possible cause (column 2).

Some of the conditions causing a watchdog are temporary. When such conditions are resolved, the watchdog can be cleared by cycling the vehicle from *Standby* to *Ready* using the joystick. However, other watchdogs, including all Node watchdogs, require hardware servicing. In this case, the vehicle must be in a Safe State before further action is performed.

Table 1: Watchdog Chart

Watchdog	Causes	OCU / Vehicle response	Troubleshoot / Operator response
Driving Command Watchdog	1. bad communications link 2. Vehicle hardware failure 3. OCU failure 4. Joystick unplugged	After 0.5 seconds, vehicle and flail go into *Standby*	1. a. check Ethernet cables (connection) b. check power on base radio c. realign and/or raise base antenna d. if there are no visible antenna line-of-sight blockages and if it is physically possible, move base antenna set-up closer to the vehicle until connection is reestablished 2. Cycle the Remote switch on the vehicle. If condition persists, report error condition. 3. a. check power to the laptop b. if OCU is running and not responding, hit <CTRL-ALT-DEL> and terminate OCU program c. restart OCU program 4. a. shutdown OCU program b. reconnect joystick c. restart OCU program after 10 seconds
Heartbeat Watchdog	1. bad communications link 2. Vehicle hardware failure 3. OCU failure	After 1 second, • vehicle and flail go into *Standby* • Communication LED blinks ONCE every 2 seconds After 10 minutes, • Drive and Power Pack engines are killed • Ignition to Drive engine and Power Pack engine are killed • Strobe light stops flashing • Vehicle is in emergency condition	1. a. check Ethernet cables (connection) b. check power on base radio c. realign and/or raise base antenna d. if there are no visible antenna line-of-sight blockages and if it is physically possible, move base antenna set-up closer to the vehicle until connection is reestablished 2. Cycle the Remote switch on the vehicle. If condition persists, report error condition. 3. a. check power to the laptop b. if OCU is running and not responding, hit <CTRL-ALT-DEL> and terminate OCU program c. restart OCU program. If vehicle is in emergency condition, a. reestablish connection with OCU b. request control of vehicle c. clear E-Stop on joystick d. make sure mode selector switch is out of IGNITION OFF setting e. crank drive and power pack engines
Communication Watchdog	1. bad communications link 2. radio down	After 1.2 seconds, • vehicle and flail go into *Standby* • Communication LED turns OFF After 3 seconds, • OCU flashes red COMM LINK warning	1. a. check Ethernet cables (connectivity) b. check power on base radio c. realign and/or raise base antenna d. if there are no visible antenna line-of-sight blockages and if it is physically possible, move base antenna set-up closer to the vehicle until connection is reestablished 2. a. check power on base radio b. once vehicle is in safe state, check power on radio inside the vehicle cab

VCU Watchdog	Vehicle software error	After 1 seconds, • vehicle goes into vehicle *Standby* and flail *Standby* • Heartbeat LED turns OFF	Cycle the Remote switch on the vehicle. If condition persists, report error condition
Node 1 Error	Vehicle hardware error	After 0.2 seconds, vehicle and flail go into *Emergency*	Cycle the Remote switch on the vehicle. If condition persists, report hardware error
Node 2 Error	Vehicle hardware error	After 0.2 seconds, vehicle and flail go into *Emergency*	Cycle the Remote switch on the vehicle. If condition persists, report hardware error
Node 3 Error	Vehicle hardware error	After 0.2 seconds, vehicle and flail go into *Emergency*	Cycle the Remote switch on the vehicle. If condition persists, report hardware error
Node 4 Error	Vehicle hardware error	After 0.2 seconds, vehicle and flail go into *Emergency*	Cycle the Remote switch on the vehicle. If condition persists, report hardware error
Node 5 Error	Vehicle hardware error	After 1 second, vehicle goes into vehicle *Emergency* and flail *Emergency*	Cycle the Remote switch on the vehicle. If condition persists, report hardware error
Node 6 Error	Vehicle hardware error	No gear feedback is available	Cycle the Remote switch on the vehicle. If condition persists, report hardware error

CAUTION

When transitioning from *STANDBY* to *READY*, all switches must be in the inactive position, with the exception of the Hydrostatic Speed and Mode switch, to ensure no damage to the vehicle occurs.

Putting the vehicle in a *Safe State* requires actions on both the OCU and vehicle. The sequence of actions is as follows:

On the OCU joystick:

1. Place the STANDBY-READY switch in *STANDBY*.
2. Momentarily put Drive Engine Crank switch to *STOP*. This kills the drive engine.
3. Momentarily put Power Pack Engine Crank switch to *STOP*. This kills the power pack engine.
4. Put mode switch to *IGNITION OFF*. Turning the ignition off prevents further battery drain caused by the A/C running when the engines are turned off.
5. Activate (push-in) E-Stop button.

On the vehicle bumper console:

1. Put Safety switch in Safe (up) setting.
2. Put Remote switch in Manual setting. (Since this will shutdown the vehicle computers, do this step *only* when performing major vehicle maintenance).
3. Activate (push-in) bumper console E-Stop button.

Once maintenance procedures are completed, perform the reverse procedure to put the vehicle back in the Ready state.

On the vehicle bumper console:

1. Deactivate (twist out) bumper console E-Stop button.
2. Put Remote switch in Remote (right) setting.
3. Put Safety switch in Enable (down) setting.

On the OCU joystick:

1. Deactivate (twist out) E-Stop button.
2. Put mode switch to *FLAIL, DRIVE FORWARD, DRIVE REVERSE, or TRANSPORT.*
3. Crank Drive Engine.
4. Crank Power Pack Engine.
5. Put in Ready.

When the communication link has been broken, all actions on the OCU side will not have an effect on the vehicle and the vehicle goes into a safe state. In this situation, either resolve to get the communication link back or the Watch Dog will take over and after 10 minutes the vehicle engines shut-off and the bumper strobe light stops flashing. At this point it is safe to approach the vehicle and perform the necessary steps to put the vehicle in a *Safe State*.

Hydrema Operational States

The Hydrema remote operation is broken down into two components, *Vehicle* and *Flail*. Both *Vehicle* and *Flail* operational states include *Ready*, *Standby*, and *Emergency*. These states are viewed on the OCU and are applicable only if the vehicle bumper switch is in Enable (refer to the Operator's Guide and the Hydrema Safety Chart).

The following *Vehicle* states are displayed in the main window of the OCU:

1. ***Ready*** – vehicle is ready to operate. No Watchdogs set.
2. ***Standby*** - vehicle goes into stationary mode. The parking brake is applied. All driving functions are not available while in standby. When automatically transitioning from Ready to Standby, vehicle goes through a safety shutdown (refer to Figure 1).
3. ***Emergency*** – all vehicle operations are locked out. Also, vehicle ignition is turned off. Emergency condition occurs when:
    a. The vehicle experiences a hardware error. The vehicle would require immediate servicing.
    b. The operator presses the E-Stop button. This condition can be reversed by resetting the E-Stop button. The vehicle goes back to *Standby* state.

The following *Flail* operational states are displayed in the Flail tab of the OCU:

1. ***Ready*** – flail is ready for operation. This condition is applicable only in Transport and Flail modes.
2. ***Standby*** – flail operation is stopped. When transitioning from *Ready* to *Standby*, the flail goes into a Flail Safe condition. Refer to Figure 1.
3. ***Emergency*** – flail operation is locked out. Flail *Emergency* and vehicle *Emergency* are always set at the same time.

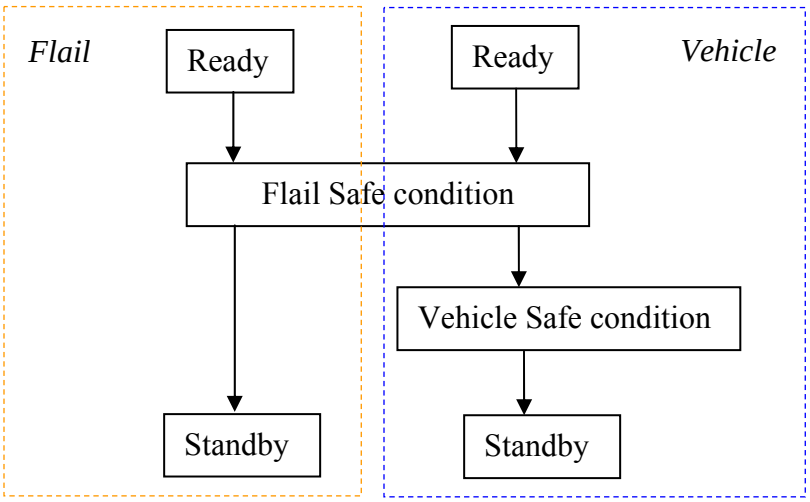


Figure 1: Vehicle state transition from Ready to Standby.

Flail Safe condition – When the flail is in operation, going into a Flail Safe condition causes an automatic shutdown of the flail (in the ideal sequence an operator should do it). This process is indicated on the OCU flail tab as FLAIL SAFE SEQ (flail safe sequence). Initially, the flail is raised to a safe height and the hydrostatic driving is halted. Flail rotation is then stopped, RPMs are dropped, and flail operation is locked.

Vehicle Safe condition – With the flail in safe condition, vehicle motion is stopped. The wheel brake is applied until vehicle is completely stopped. Finally, the parking brake is engaged. Going into vehicle safe condition is not reflected on the OCU until it is completed and *Standby* appears on the main window.

NOTE

If during the operation or set up of the MACV, one of the Operator Control Unit (OCU) Switches is placed or turned to the incorrect position an Error Message will pop up on the OCU for a period of five (5) seconds and then go away. At this time placing the switch in the correct position will not cause the Error Message to go away.

Section 1

Remote Control Setup Procedures

The Operator Control Station (OCS) is contained in two cases and consists of the following equipment items:

Hydrema T-1 – OCS Storage Box 1 of 1

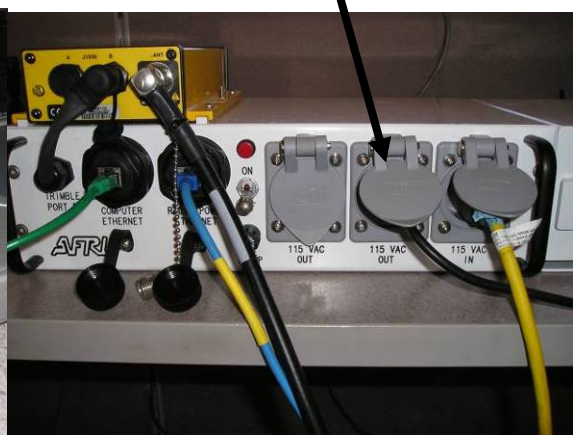
- Laptop Computer (OCU) with power cord for 110V operations
- Joystick Box (JB) with USB cable
- COM/GPS Case

Hydrema T-1 – Antenna Storage Box 1 of 1

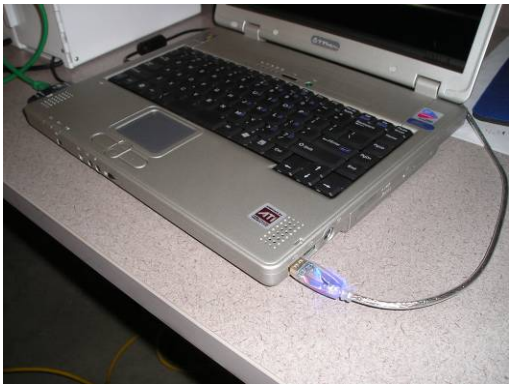
- GPS antenna, and antenna cable
- Ethernet radio, antenna, and antenna cable

Set Up

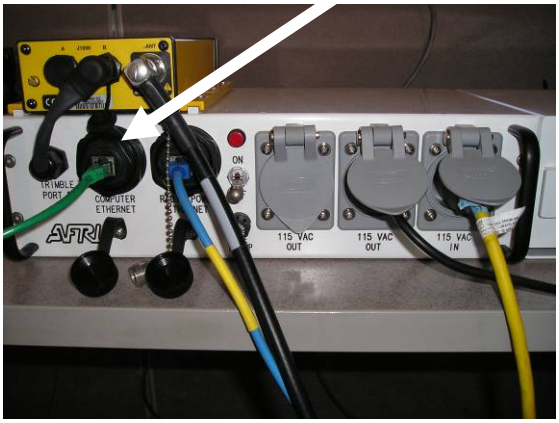
1. Connect Laptop power cable to laptop and to one of the 115 VAC power source outlets on the COM/GPS panel



2. Connect USB cable from Joystick Box to Laptop



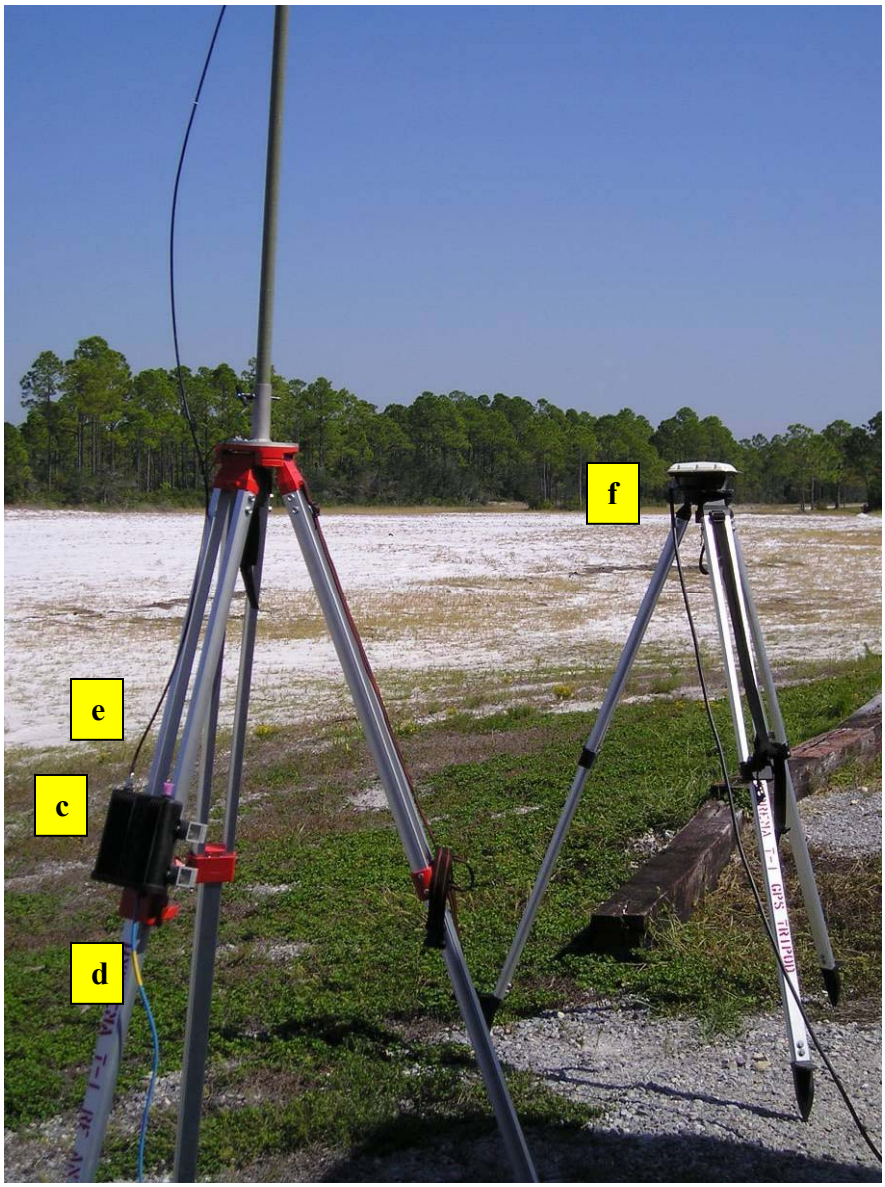
3. Connect Ethernet cable from COM/GPS case to Laptop



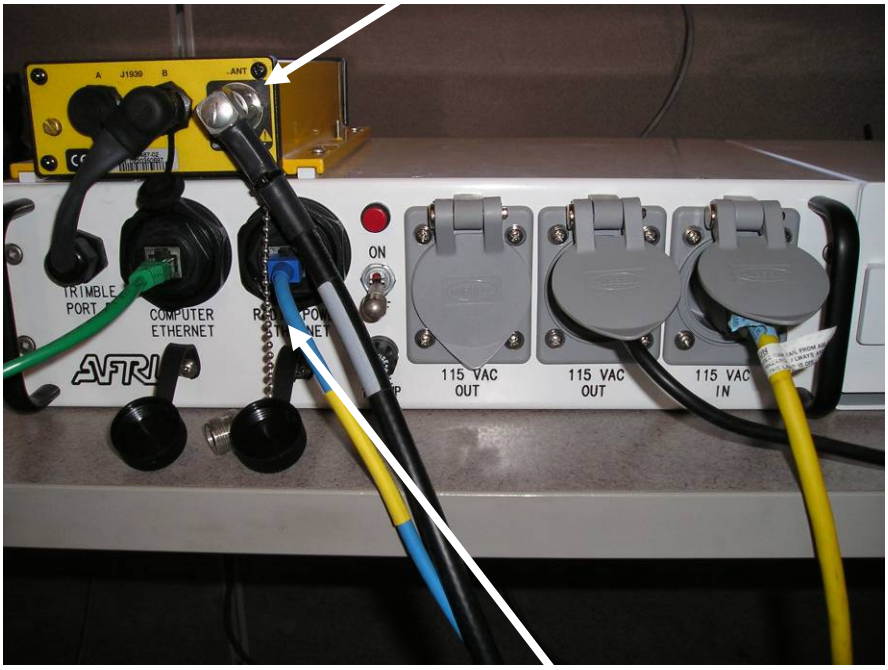
Note: Place antennas in an open area, failing to do so will reduce signal reception and remote vehicle operating distance.

4. Set up the Vehicle Radio Control and GPS Antennas by:

a. Set up the 2 tripods
b. Attach RF and GPS antennas to tripod
c. Mount the Esteem Radio to the leg of the RF antenna tripod
d. Connect the Ethernet cable to the Esteem radio
e. Connect the short RF radio antenna cable from the Esteem radio to the radio antenna (not shown)
f. Connect the large diameter GPS antenna cable to the GPS antenna



5. Connect GPS antenna cable to COM/GPS case

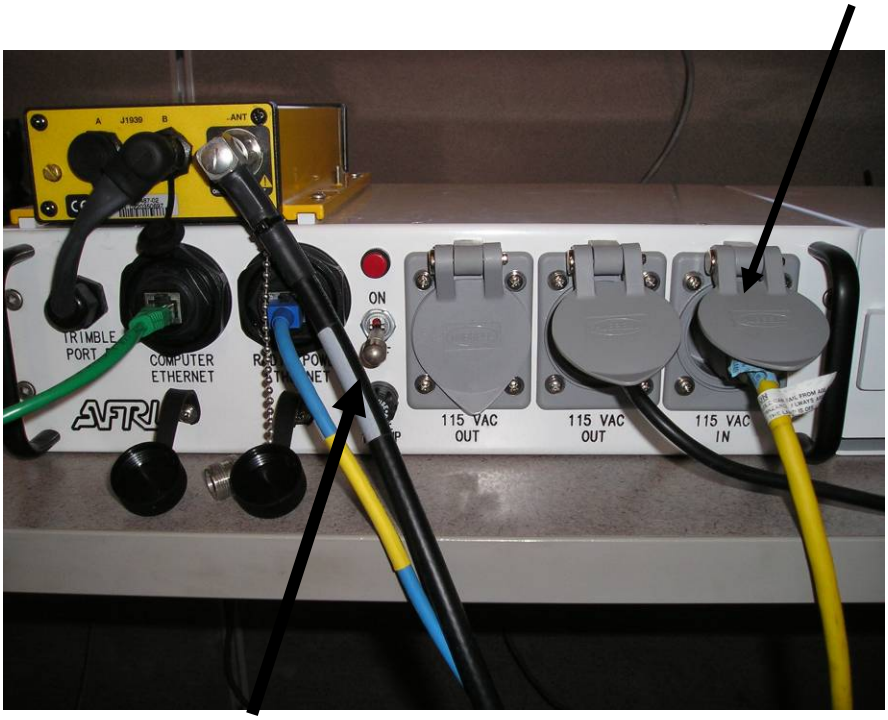


6. Connect Radio Power Ethernet cable to COM/GPS case

WARNING

Ensure the 115VAC power source is 60Hz, using other than 60Hz may damage or cause the system to not operate properly.

7. Connect 115 VAC power cable to COM/GPS case and to a 115 VAC power source (generator)



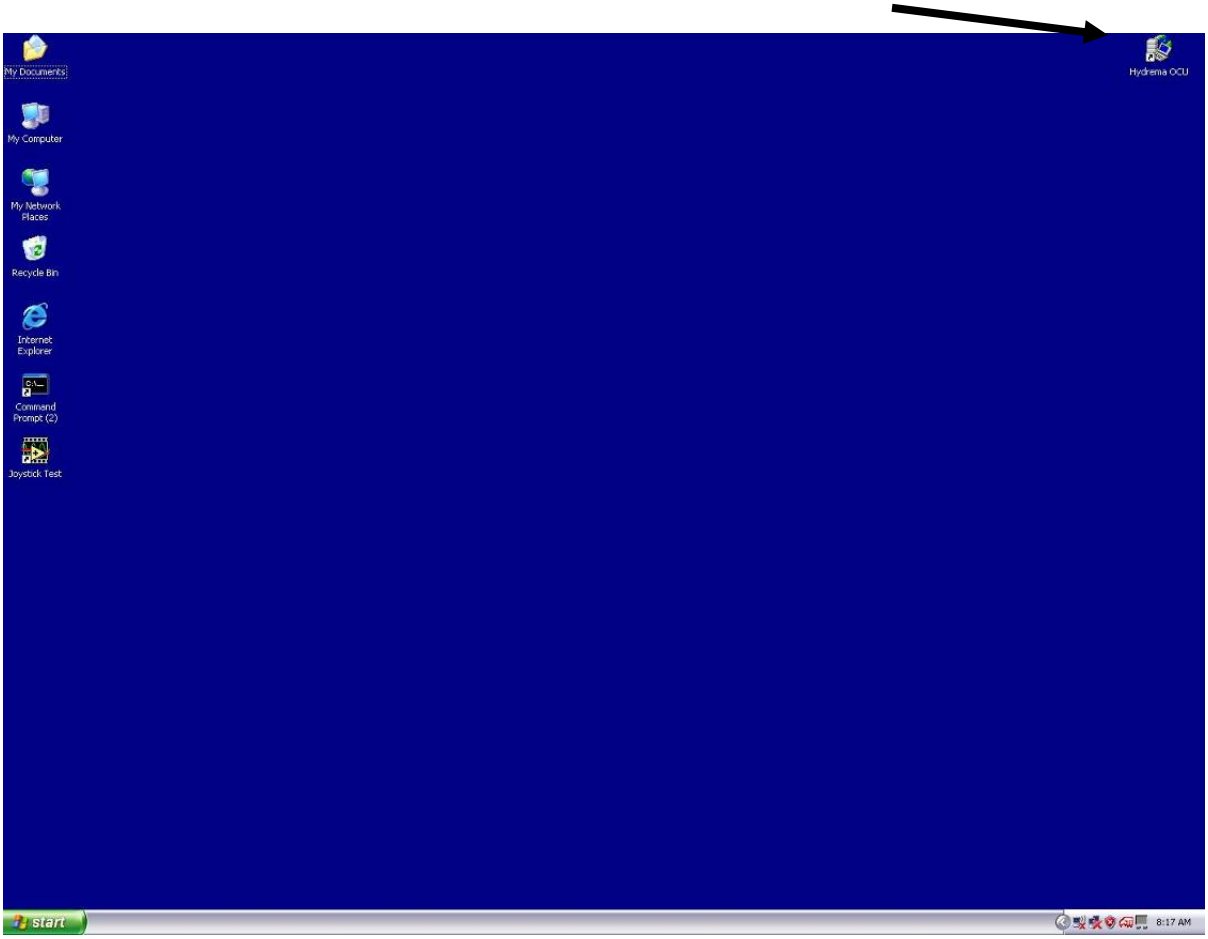
8. Turn power ON to COM/GPS case (Check to see that the red light on panel face illuminates as does the LCD display on the back of the GPS).

WARNING

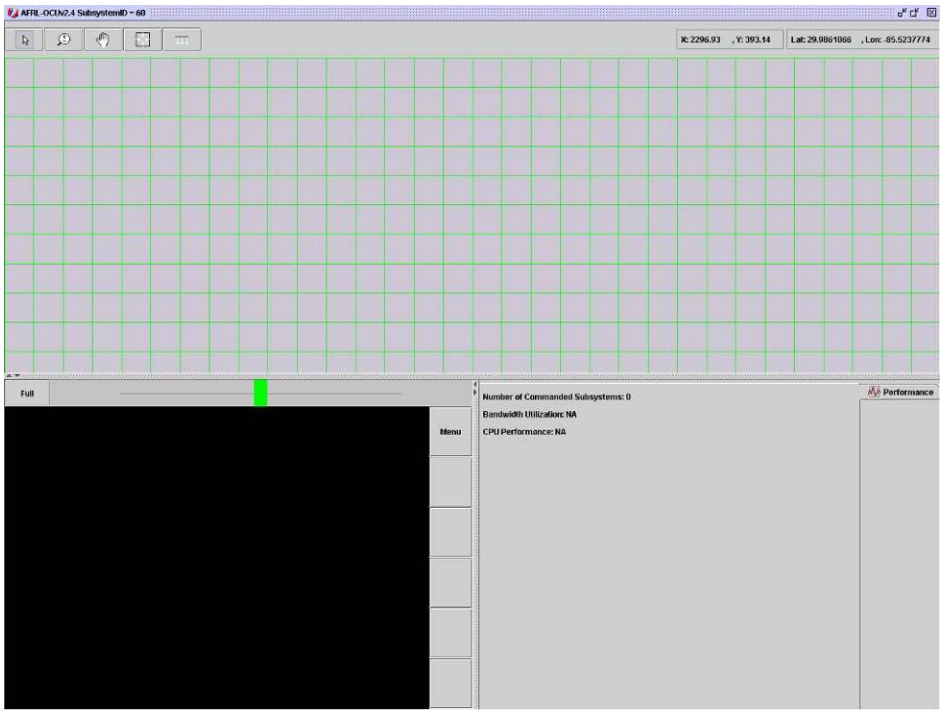
Once power has been applied to the COM/GPS system, do not unplug any of the cables. Power down the system by placing the Power Switch to the off position (down) prior to unplugging any cable connections. Doing so may cause the system to be reset to the factory defaults.

9. Open Laptop – Press power ON button. Wait for computer to boot up

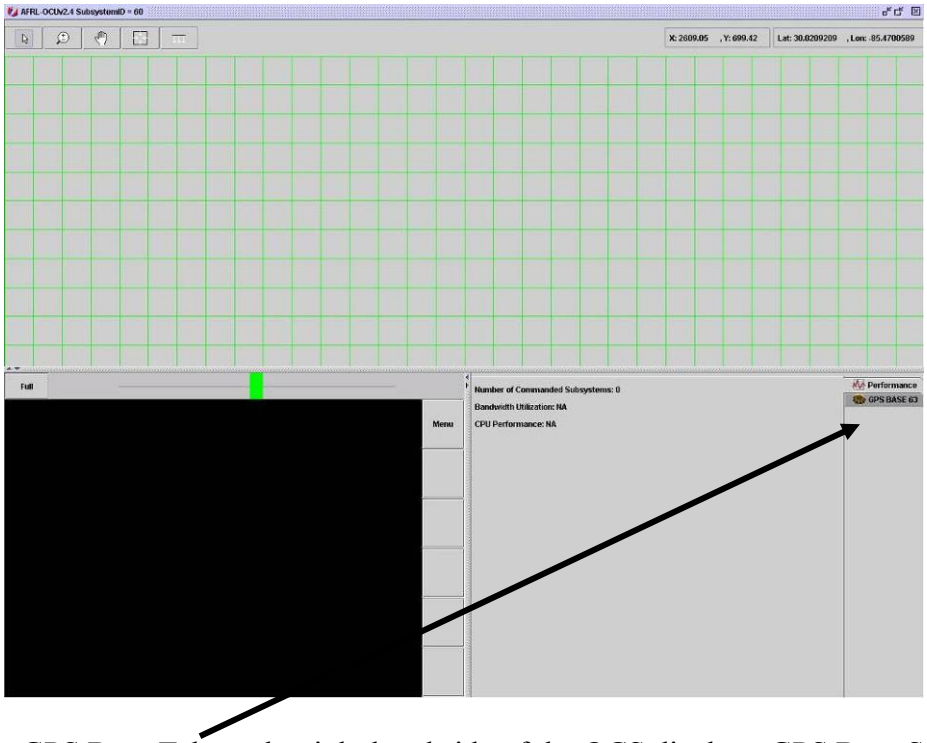
10. Launch Hydrema OCU – upper right hand corner of monitor by double clicking on the icon



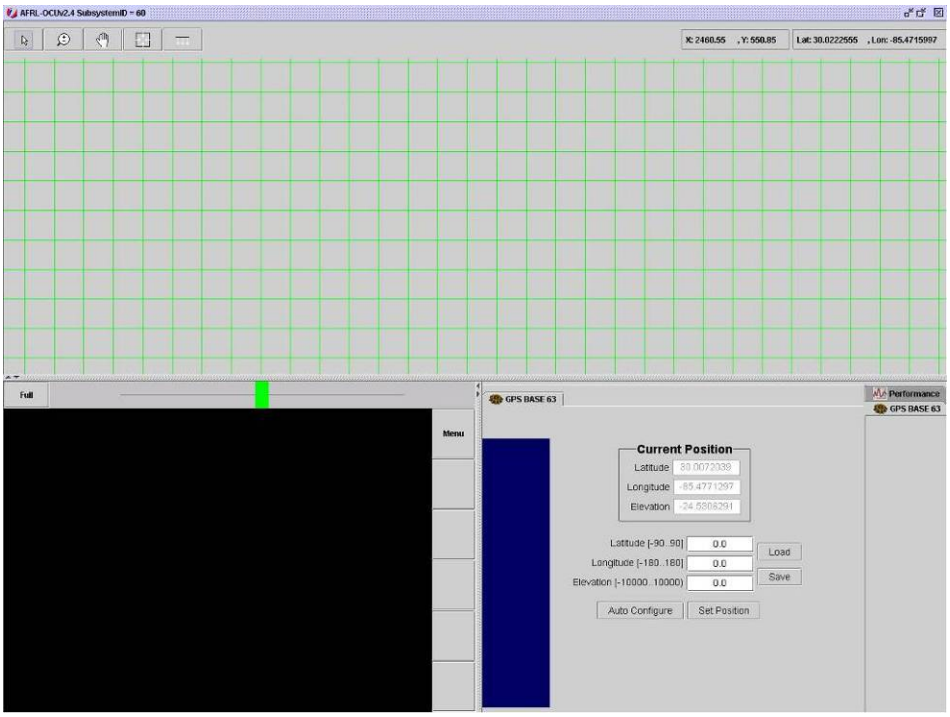
11. MACV OCU will appear as pictured below when it completes startup.



Once both the COM / GPS base station & OCS have completed booting up, the following screen should appear on the OCS:

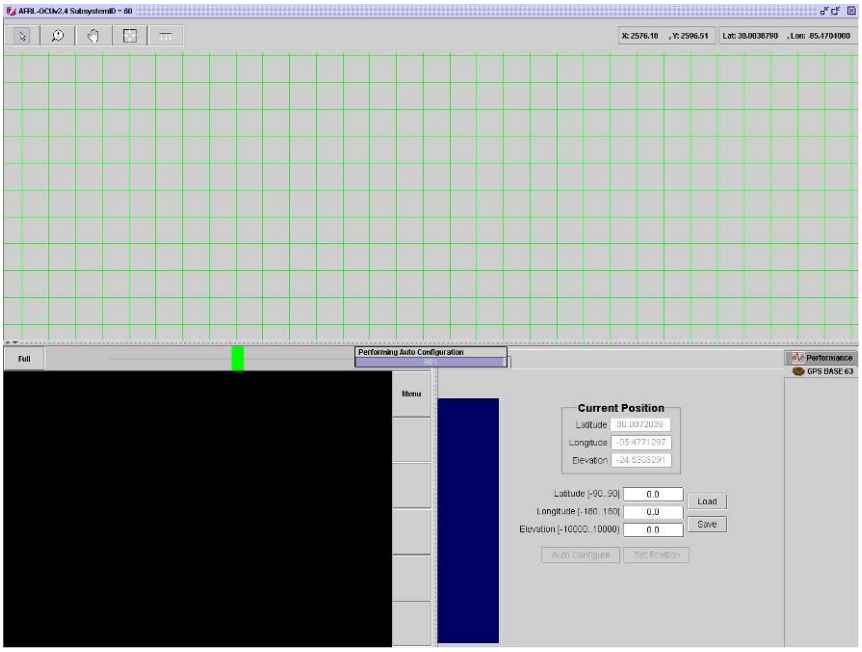


12. Select the GPS Base Tab on the right hand side of the OCS display. GPS Base Screen appears (pictured below).



NOTE: Daily, or each time the remote system is moved to another location, or the system is powered up, the GPS Base Station must go through an auto-configuration cycle to ensure the vehicle GPS position is accurately established and maintained.

13. Wait at least two (2) minutes prior to performing the following GPS Base Station auto-configuration. Perform auto-configuration by toggling on the Auto Configure Tab. This step may take up to three (3) minutes top complete and the screen will appear as follows:

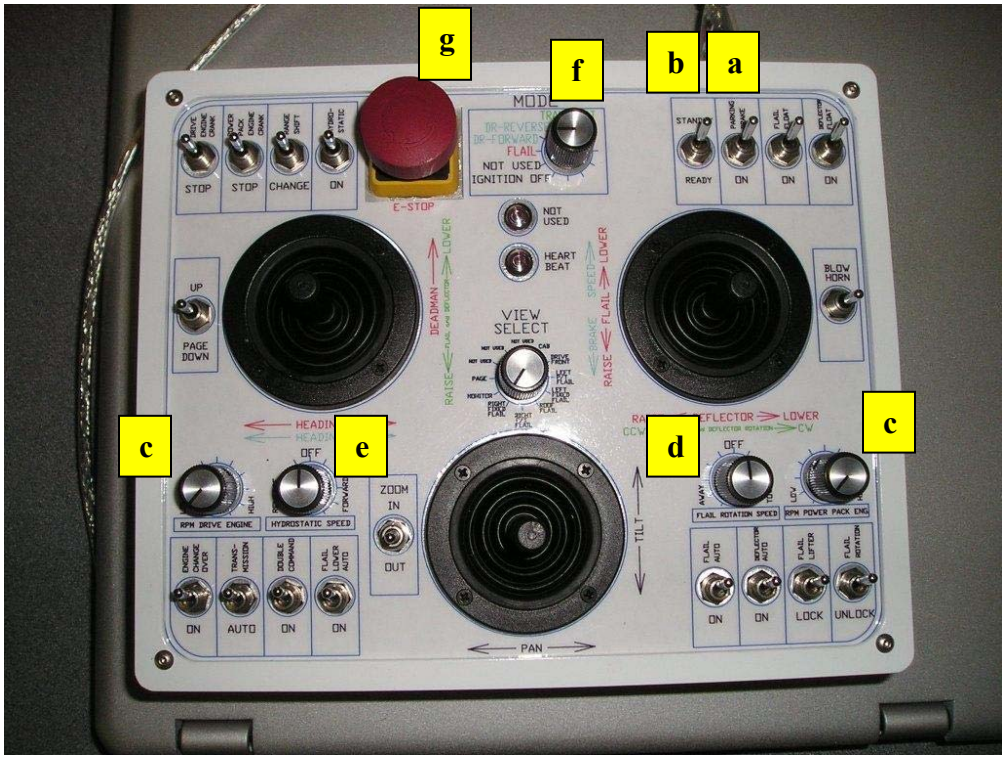


14. When the GPS Base Station has completed the auto-configuration cycle the Current Position on the GPS Base Tab is updated. If an error occurs after the auto-configuration, complete the following steps:

a. Repeat the auto configuration procedure
b. If error persists, check GPS antenna connection/setup, cycle the power on the COM/GPS case, and repeat the auto configuration procedure
c. **If the error still occurs, call AFRL/RXQF, Robotics Research Team at DSN 523-3725, commercial (850) 283-3725 or email Marshall Dutton; marshall.dutton.ctr@tyndall.af.mil**

NOTE

If during the operation or set up of the MACV, one of the Operator Control Unit (OCU) Switches is placed or turned to the incorrect position an Error Message will pop up on the OCU for a period of five (5) seconds and then go away. At this time placing the switch in the correct position will not cause the Error Message to go away.



15. Initial Joystick Set Up Procedures:
    Activate Parking Brake switch **"a"** to ON position
    Activate STANDBY-READY Switch **"b"** to STANDBY position**. (NOTE: When the STANDBY-READY Switch is in the STANDBY position, the PARKING BRAKE Switch is over-ridden and inactive; and the vehicle brakes are on. When the STANDBY-READY Switch is in the READY position, the PARKING BRAKE Switch is active and may be used.)**
    Rotate Drive Engine & Power Pack Engine RPM knobs **"c"** (both) to the Low position. This puts the engines in Idle
    Rotate Flail Rotation Speed knob **"d"** to OFF position
    Rotate Hydrostatic Speed knob **"e"** to OFF position
    Rotate MODE Switch **"f"** to desired position (TRANSPORT, DR-REVERSE, DR-FORWARD, or FLAIL)
    E-STOP Button **"g"** to Out position
16. Proceed to the Hydrema vehicle.

The Hydrema vehicle is manually driven to a site where flailing operations are to be conducted. A manual test run is performed within a safe area to establish flailing parameters. Both engines

are stopped and the ***parking brake is set***. The operator then configures the cab for remote operations by performing the following steps:

17. **Vehicle Drive Dash Board**

Drive Engine Ignition – OFF (Position P)

All ROCKER switches Inactive **(Note: If the rocker switches are left in the active state, remote operation of the particular switch will not be possible, with the exception of the Parking Park.)**

Gearshift in NEUTRAL and LOCK

Ensure Gear Select Switch (on left hand side of steering console) is in the #1 position.

18. Rotate seat to Flail Position (facing aft)

19. **Seat Console**

All ROCKER switches Inactive
Parking brake Active
Stop button Out

20. **Flail Dashboard**

Power Pack Engine IGNITION OFF (position P)
All ROCKER switches Inactive (UP) position
Flail Rotation OFF – Centered Position
Hydrostatic speed OFF – Centered Position
Both engines RPM at idle – Lowest Position
EMERGENCY STOP button OUT

21. **Locate the GPS / COM Panel on right hand bulk head with seat facing aft.**

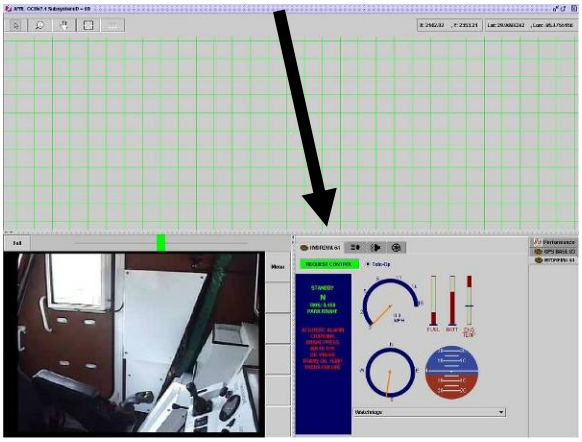
GPS Switch – ON
COM Switch - ON

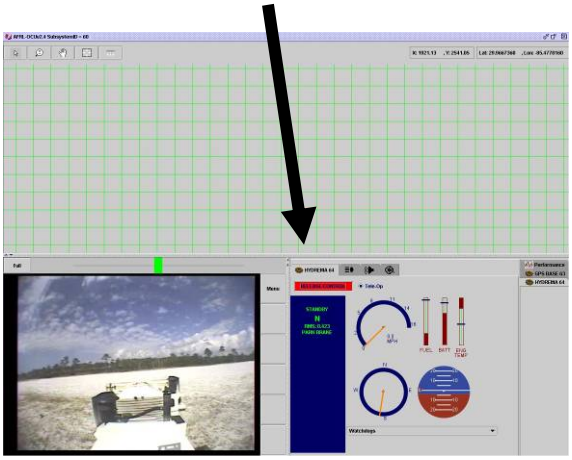
22. **Exit cab**

23. Check that both external E-STOP buttons on each side of the vehicle are in the OUT position. (At vehicle Bumper Control Console (Right front side, as sitting in Driver's Seat facing forward))

Place SAFE / ENABLE Switch to SAFE position
Activate MANUAL / REMOTE Switch to REMOTE position
Wait for Heartbeat LED to start blinking (about 10 sec)
Wait for Communication (COM) LED to start blinking (must have link with OCS)
Place SAFE / ENABLE Switch to ENABLE position

NOTE: If strobe light flashes, place SAFE-ENABLE Switch to the SAFE position, cease operations and determine if someone at the OCS has REQUESTED CONTROL (the REQUEST CONTROL BUTTON) is RED or someone or something has gained radio control of the remote system. If it is determined someone REQUESTED CONTROL, push the RED RELEASE CONTROL BUTTON to change it to the GREEN REQUEST CONTROL BUTTON. If someone has not REQUESTED CONTROL, determine where the radio signal is coming from prior to continuing operations.

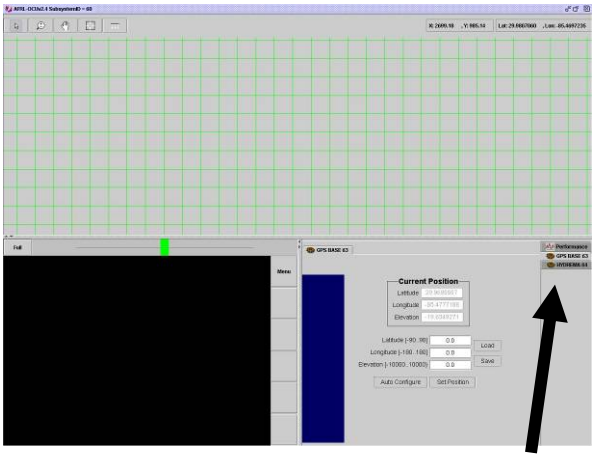


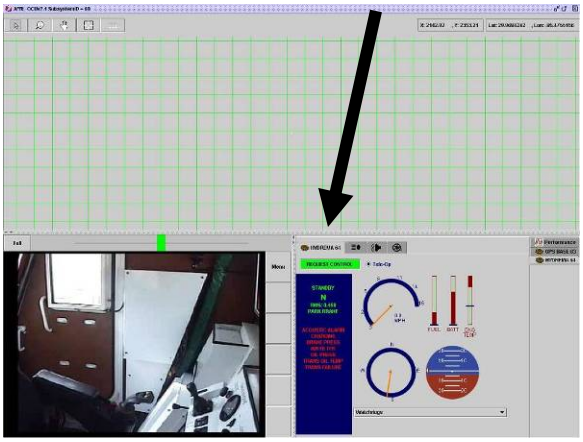


If after completing these steps, the strobe continues to flash, place the SAFE- ENABLE Switch back into the SAFE position and attempt to reboot the remote system by moving the REMOTE / MANUAL Switch on the vehicle bumper from REMOTE to MANUAL and then back to the REMOTE position. If the strobe continues to flash, CEASE all remote operations and call AFRL/MLQF, Robotics Research Group at DSN 523-3725, commercial (850) 283-3725 or email Marshall Dutton; marshall.dutton.ctr@tyndall.af.mil

24. **Proceed back to OCS**

Note: If Hydrema Tab on the right side of the OCS does not light up; communications have not been established and cable connections need to be rechecked.





25. Click on the HYDREMA 64 BUTTON on the OCS and screen above should appear with the Green REQUEST CONTROL BUTTON available.

Note: For all remote control operations:

The Joystick Box and the Laptop screen becomes the vehicle's dashboard and cab monitor

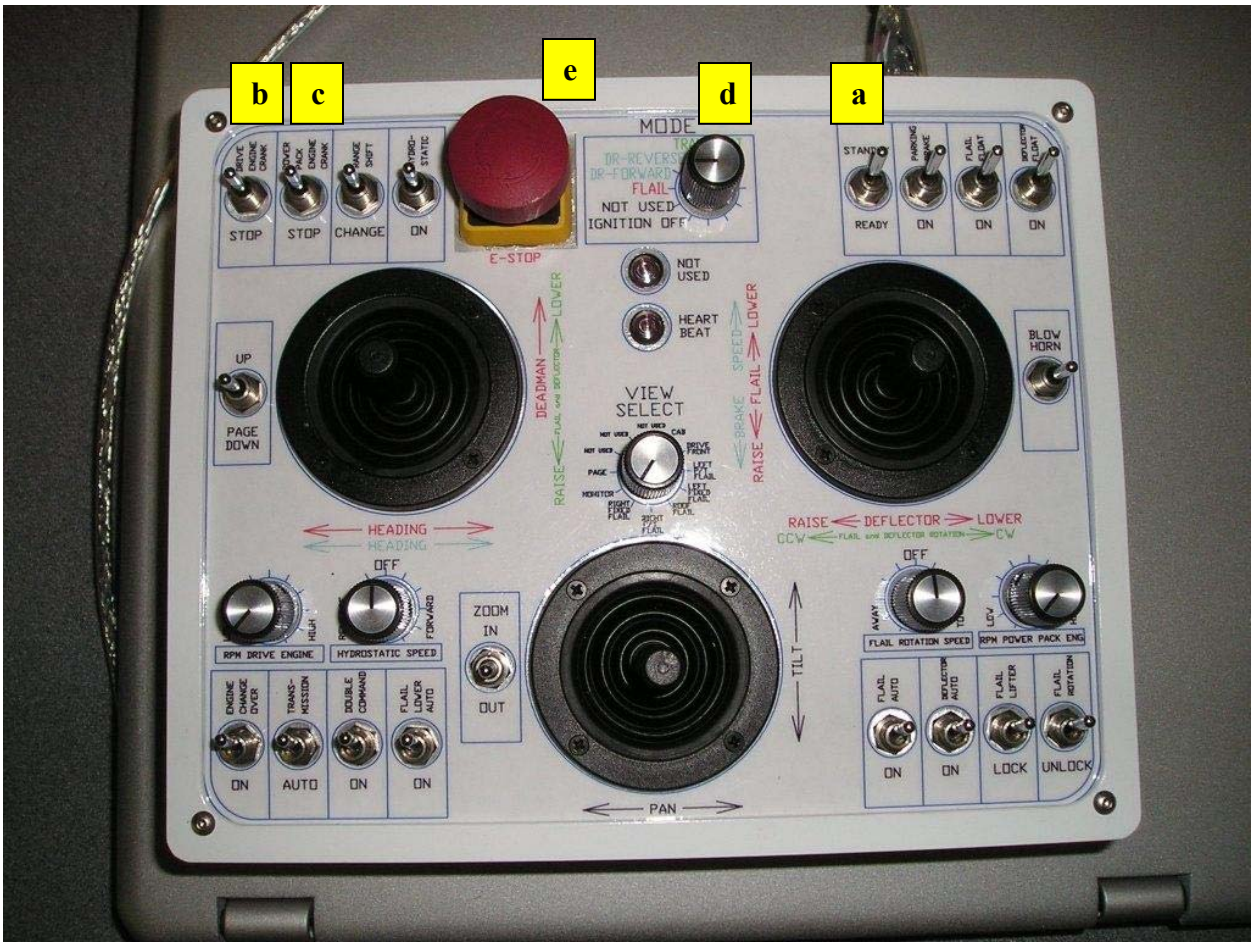
Use View Select to select camera views 1 through 7 (positions 1-4 have pan/tilt and zoom capabilities)

Use Page Mode to obtain quad view on monitor screen (page up/down to change camera views)

Use View Select to select the cab MONITOR

Use the monitor function buttons on the Laptop to select desired function

25. When joystick is unattended perform the following procedures on Joystick Box by:

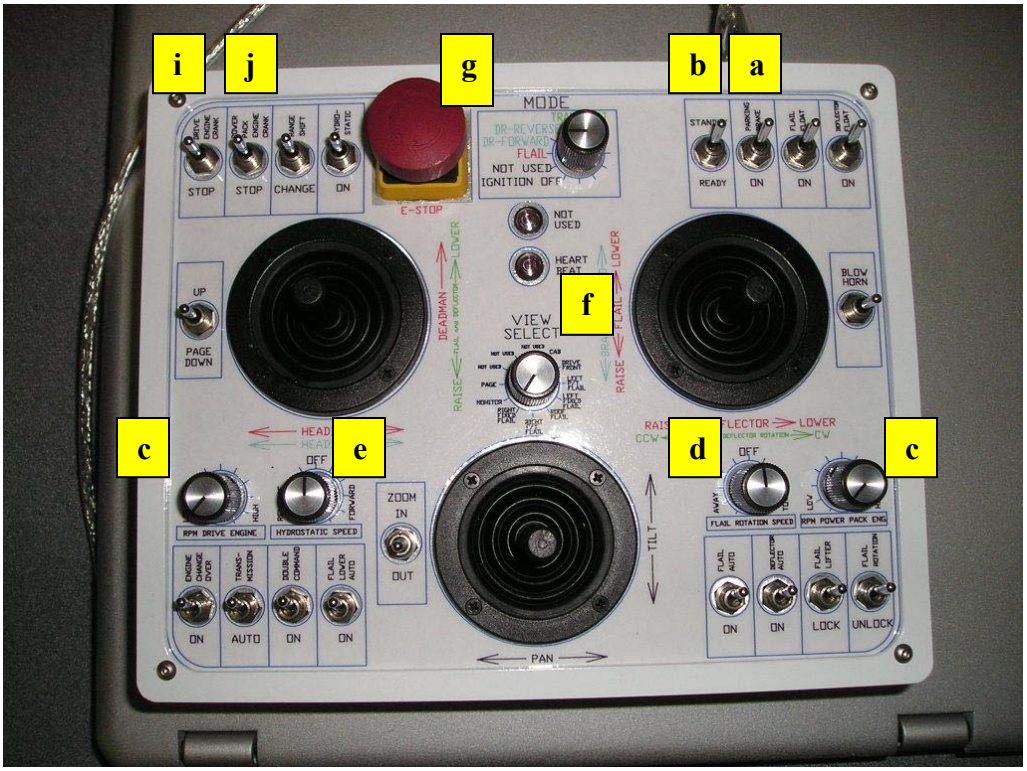


Place the STANDBY-READY **"a"** switch in STANDBY.
Monetarily put Drive Engine Crank switch **"b"** to STOP. This stops the drive engine.
Monetarily put Power Pack Engine Crank switch **"c"** to *STOP*. This stops the power pack engine.
Put MODE switch **"d"** to IGNITION OFF . Turning the ignition off prevents further battery drain caused by the A/C running when the engines are turned off.
Activate (push-in) E-Stop button **"e".**

Section 2

Remote Vehicle Travel Operations

All remote control operations of the Hydrema vehicle are implemented by the operator through the Operator Control Unit (Joystick Box). A photograph of the OCU control unit is presented for operator convenience.



1. **STARTING VEHICLE**

Steps:

Perform the Initial Joystick Set Up Procedures by:

Activate Parking Brake switch **"a"** to ON position

Activate STANDBY-READY Switch **"b"** to STANDBY position. **(NOTE: When the STANDBY-READY Switch is in the STANDBY position, the PARKING BRAKE Switch is over-ridden and inactive; and the vehicle brakes are on. When the STANDBY-READY Switch is in the READY position, the PARKING BRAKE Switch is active and may be used.)**

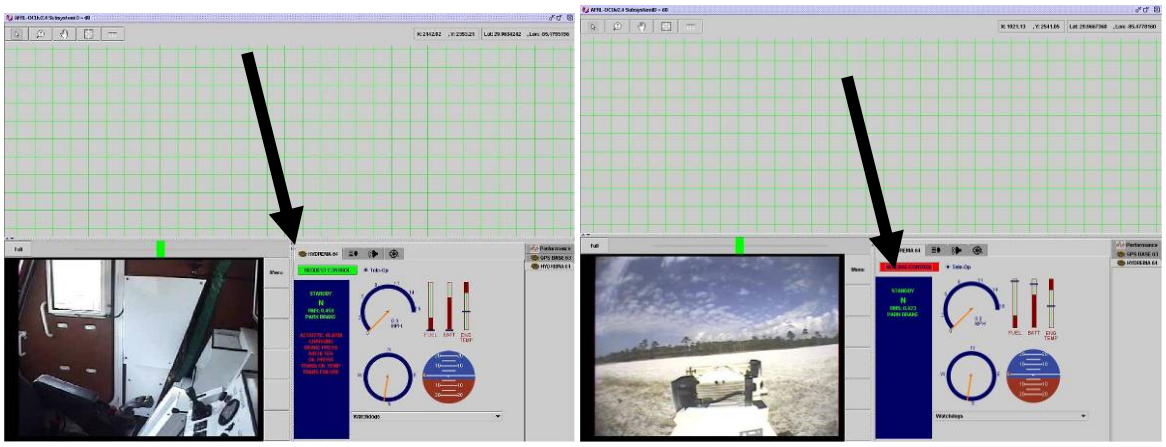
Rotate both the Drive Engine & Power Pack Engine RPM knobs **"c"** (both) to the Low position. This puts the engines in Idle

Rotate Flail Rotation Speed knob **"d"** to OFF position

Rotate Hydrostatic Speed knob **"e"** to OFF position

Rotate MODE Switch **"f"** to desired position (TRANSPORT, DR-REVERSE, DR-FORWARD, or FLAIL)

E-STOP Button **"g"** to Out position



h. Click on Select Request Control Bar (Green bar) on laptop – Turns red when control is activated

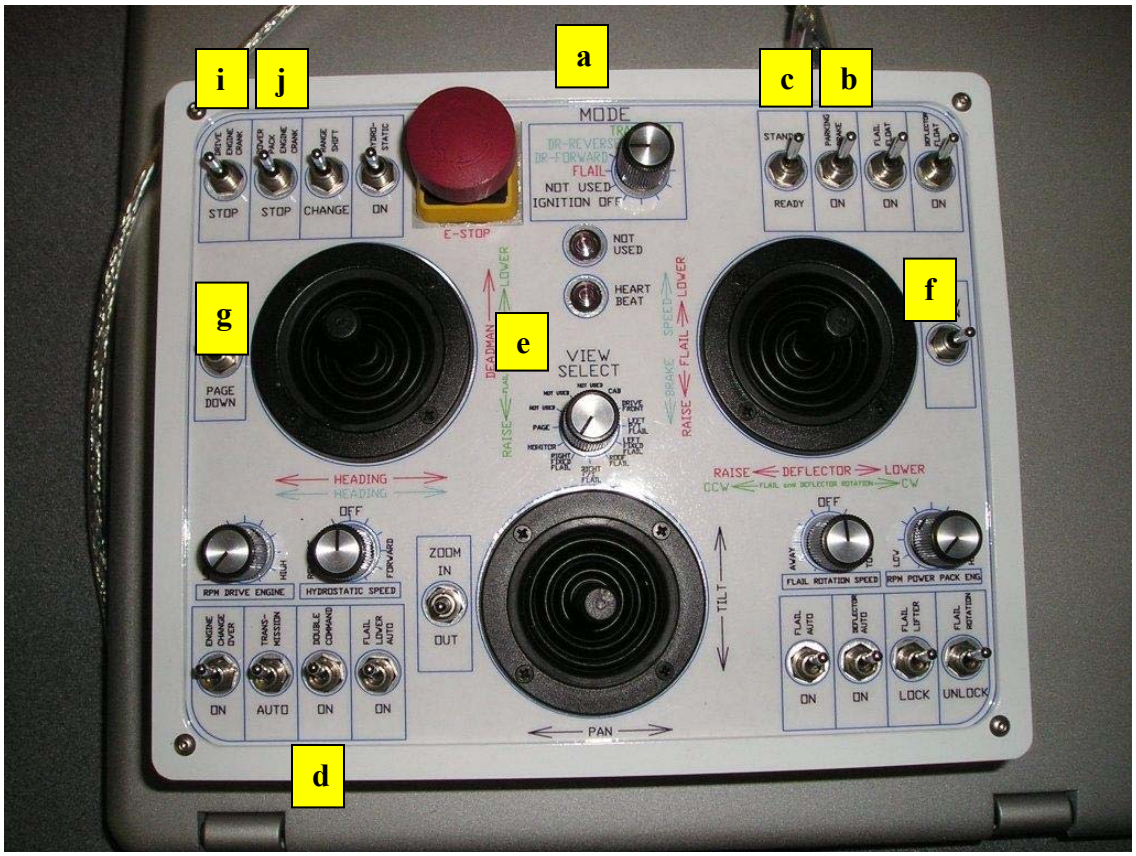
On Joystick Box

Activate Drive Engine Crank switch **"i"** momentarily (up) – this starts engine

- Check engine RPM displayed on laptop monitor

Activate Power Pack Engine Crank switch **"j"** momentarily (up) – this starts engine

- Check engine RPM displayed on laptop monitor



2. **DRIVING FORWARD**

Steps:

Rotate MODE switch **"a"** to DR-FORWARD position

Activate Parking Brake switch **"b"** to OFF position (UP)

Activate STANDBY-READY Switch **"c"** to READY position (down) (Note: Vehicle may move when this is accomplished.)

Activate Double Command switch **"d"** to ON (down) position

Turn View Select switch **"e"** to camera facing direction of travel

Use right joystick **"f"** as throttle – vehicle moves forward by pushing forward on joystick

- Vehicle stops when right joystick is released to neutral (center), pulling back increases breaking

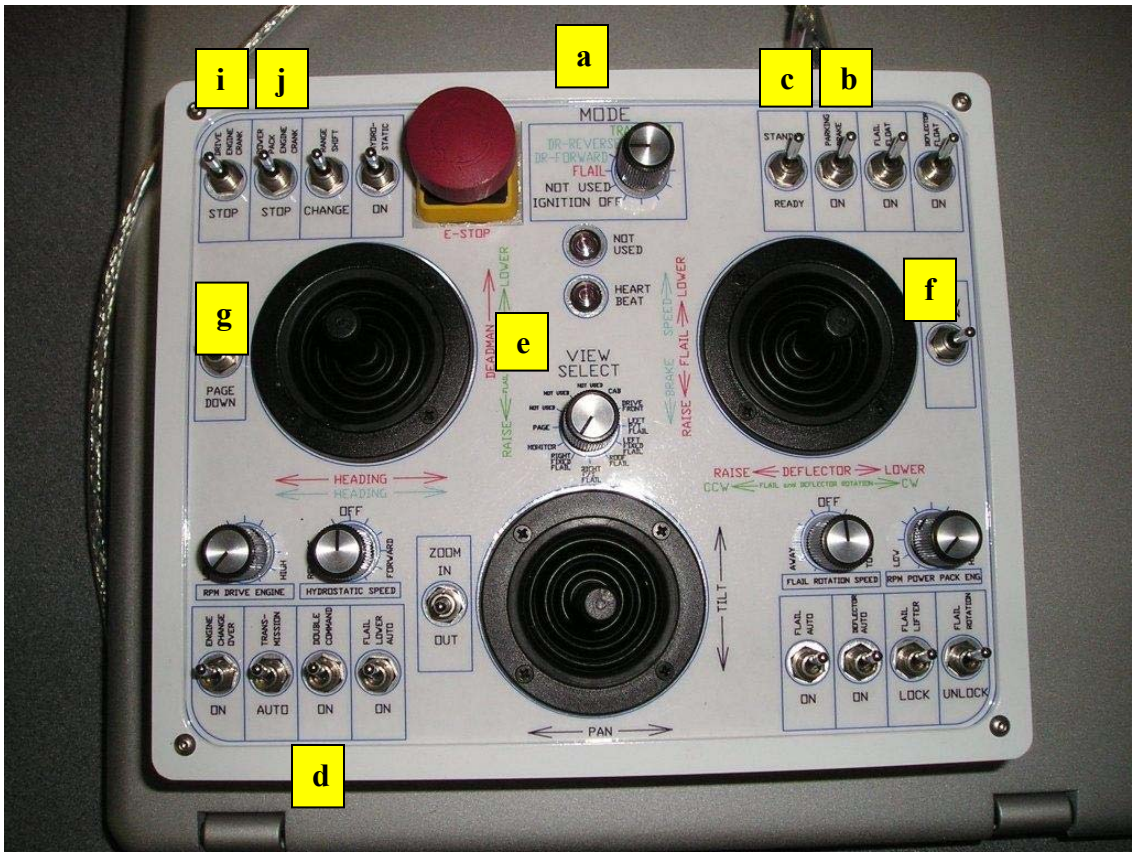
Use left joystick **"g"** to steer Right and Left

When stopped:

Activate Double Command switch **"d"** to OFF (UP) position

Activate STANDBY-READY Switch **"c"** to STANDBY position (UP)

Activate Parking Brake switch "b" to ON position (DOWN) position



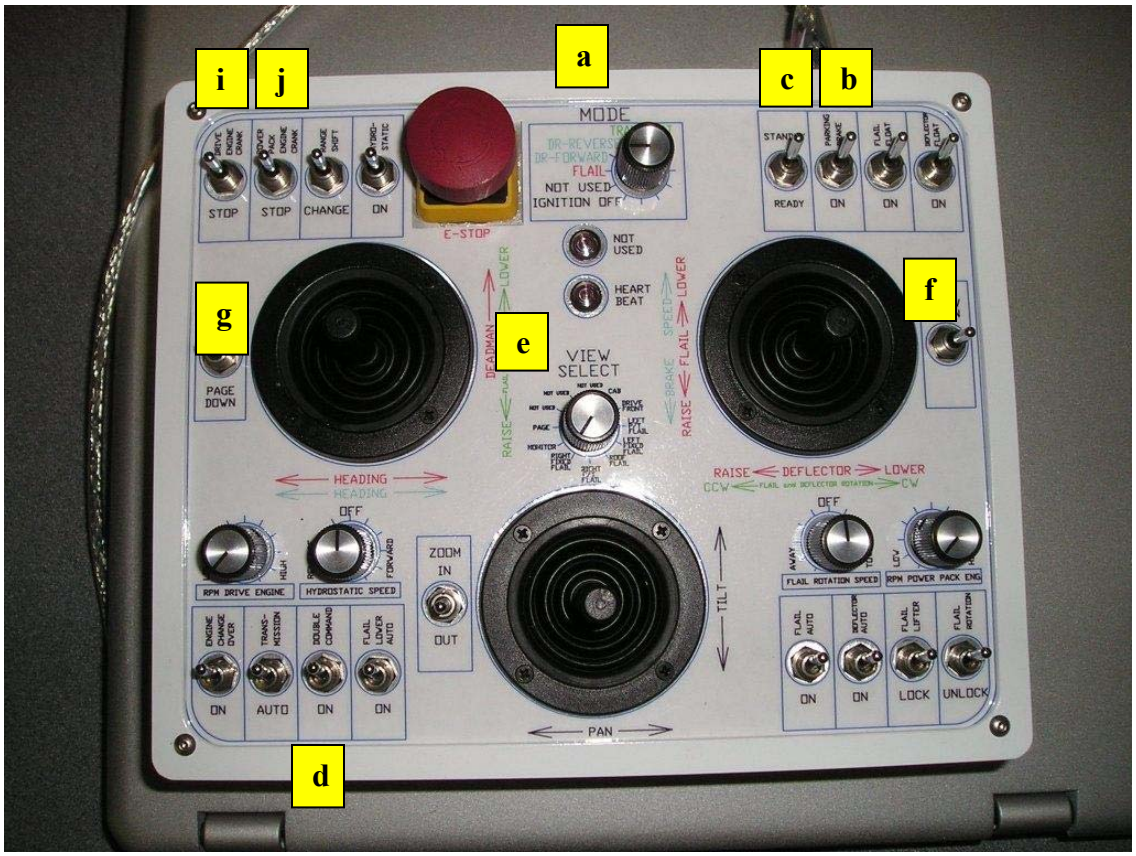
3. **DRIVING REVERSE**

Steps:

Rotate MODE switch **"a"** to DR-REVERSE position
Activate Parking Brake switch **"b"** to OFF position (UP)
Activate STANDBY-READY Switch **"c"** to READY position (down)
Activate Double Command switch **"d"** to ON (down) position
Turn Select View switch **"e"** to camera facing direction of travel
Use right joystick **"f"** as throttle – vehicle moves forward by pushing forward on joystick
- Vehicle stops when right joystick is released to neutral (center), pulling back increases breaking
Use left joystick **"g"** to steer Right and Left

When stopped:

Activate Double Command switch **"d"** to OFF (UP) position
Activate STANDBY-READY Switch **"c"** to STANDBY position (UP)
Activate Parking Brake switch **"b"** to ON position (DOWN) position



4. **TRANSPORT (Used to Deploy or Stow flail head from either position)**

Steps:

Rotate MODE switch **"a"** to TRANSPORT position

Activate STANDBY-READY Switch "c" to READY position (down)

Use left joystick "**g**" to deploy or stow flail head

Use right joystick "**f**" to rotate flail head to deployed or stowed position

Once deployed or stowed activate STANDBY-READY switch "**c**" to STANDBY position (UP)

Section 3

Remote Flailing Operations

ZEROING THE MACV STEERING

Steps:

Select the Hydrema Tab on the right hand side of the OCS display
Select Monitor using the VIEW SELECT knob on the joystick box
Using the Monitor buttons to the right of the Monitor display:

Click Menu/Steering/Select
Hold -1 until the steering deflection is 0 (see photo)

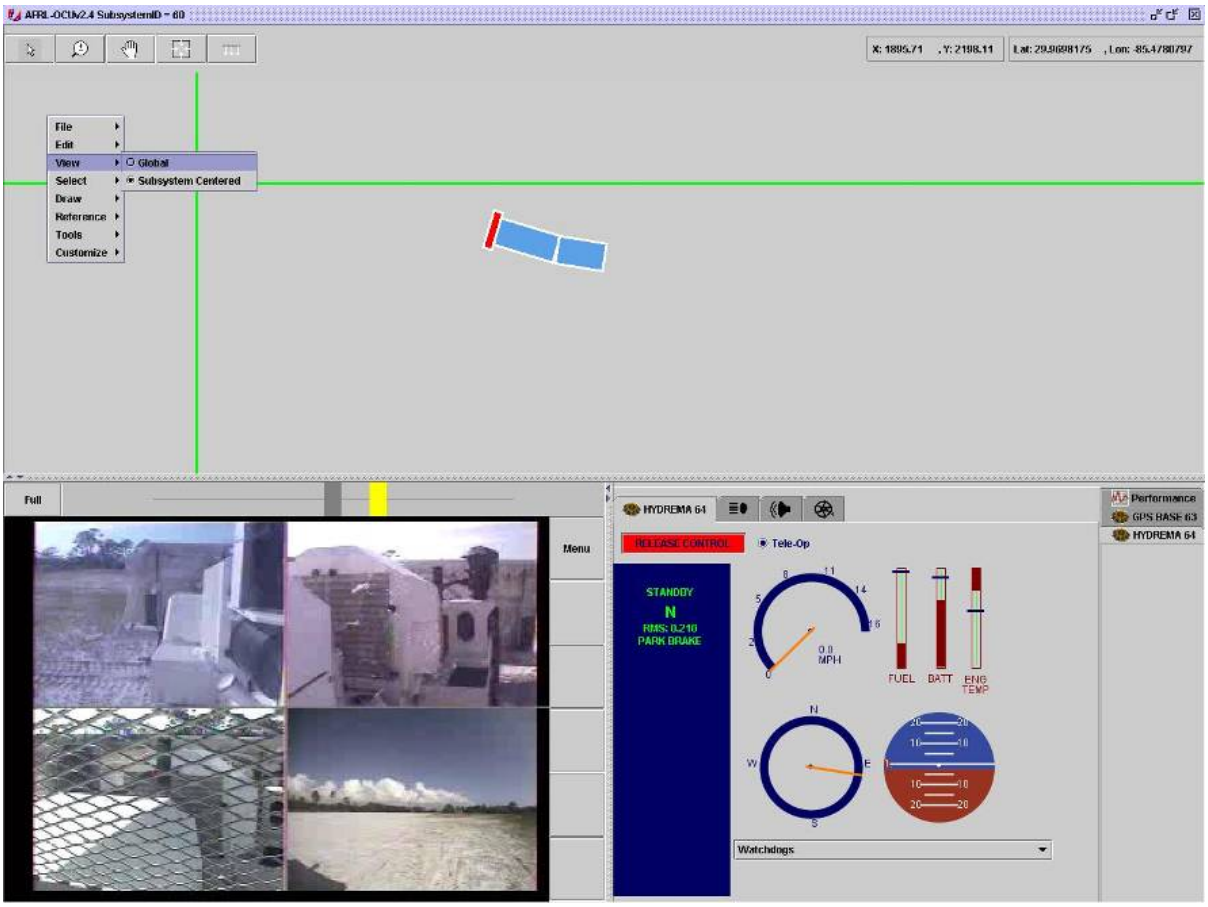
ZOOMING THE MAP DISPLAY

Steps:

Click the Zoom Tool (magnifying glass) button in the top left corner of the OCS display
Position the mouse over the Map
Press and hold the left mouse button
Drag the mouse up and down to zoom in and out

CHANGING THE MAP VIEW MODE

By default, the map will automatically pan to keep the selected subsystem (GPS Base or Hydrema) in the center of the display. Use the following steps to disable this feature:
Right click on the map
Select View/Global (see photo)



To return to the default view setting:
Right click on the map
Select View/Subsystem Centered

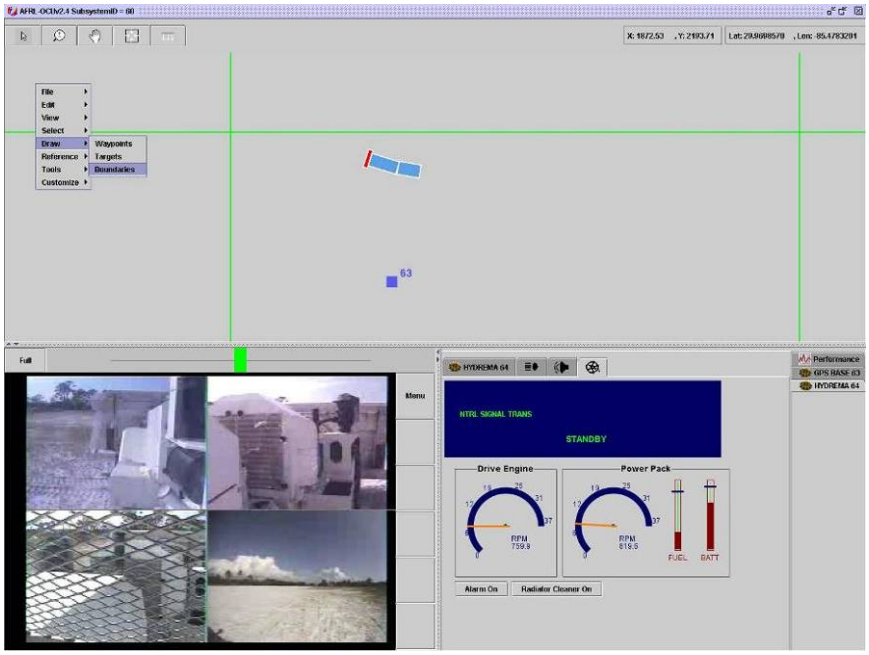
PANNING THE MAP DISPLAY

Steps:
Click the Pan Tool (hand) button in the top left corner of the OCS display
Position the mouse over the map
Press and hold the left mouse button
Move the mouse to pan the map

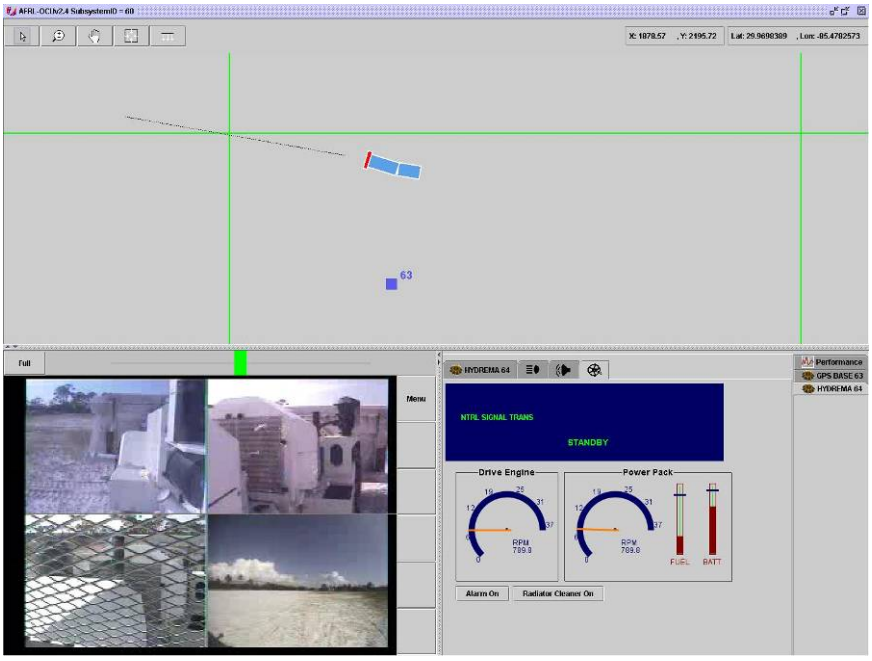
MAPPING AN AREA TO BE COVERED

Note: Changing the map view mode to Global during these steps may be preferable.

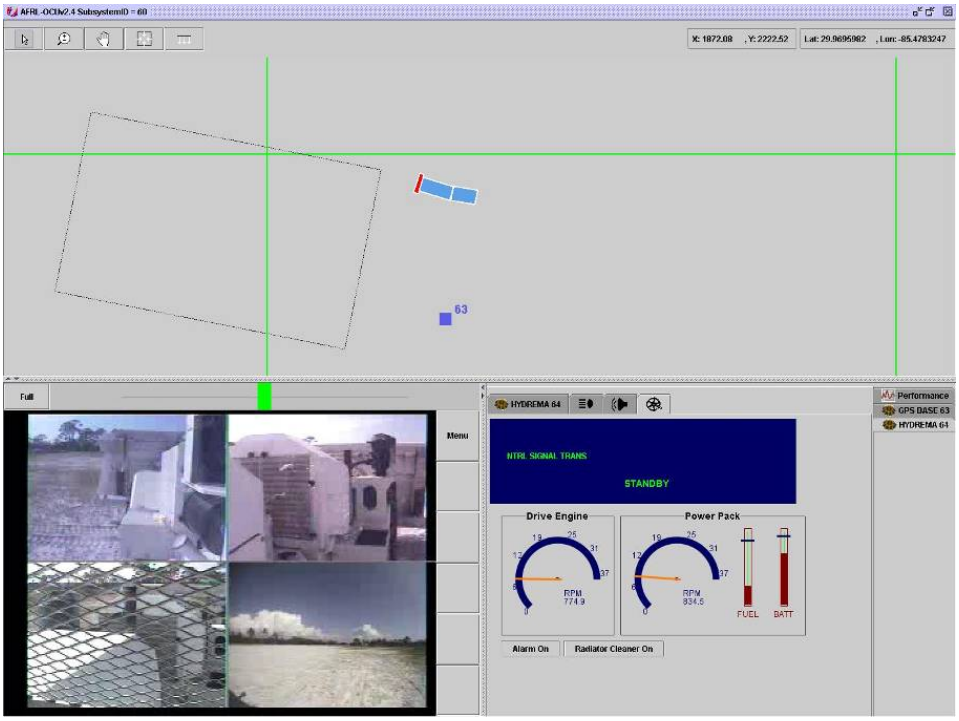
Steps:
Select the Hydrema Tab on the right hand side of the OCS display
Right click on map
Select Draw/Boundaries (See photo)



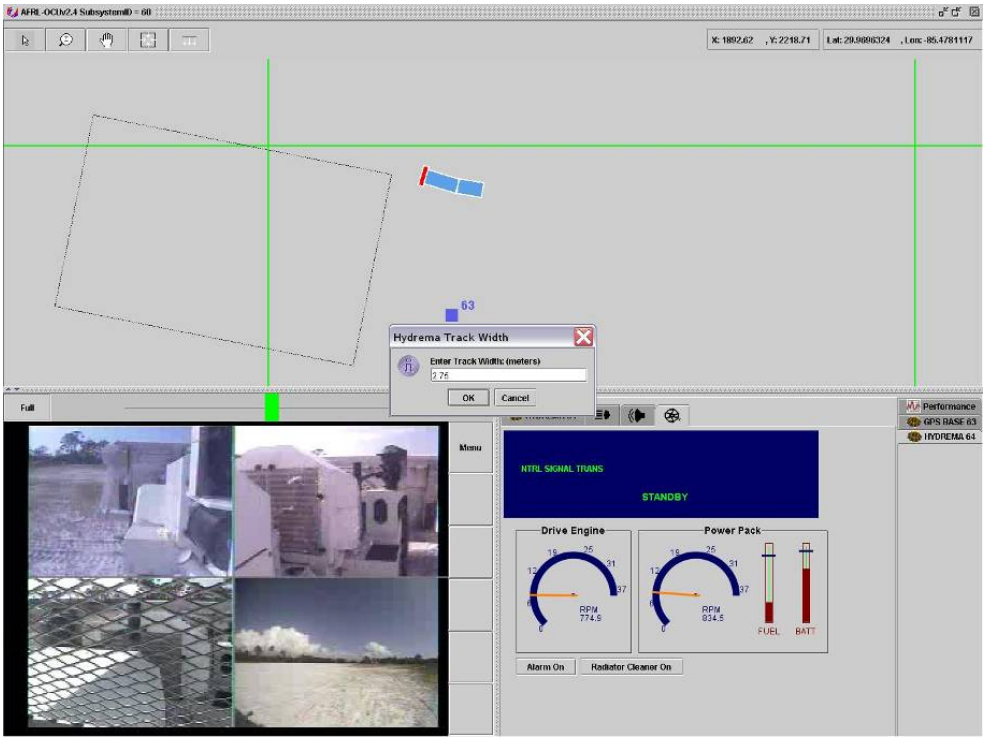
Place pointer at start point (front of flail head) and click the left mouse button
Position mouse in desired direction and distance of travel to desired end point and click the left mouse button (See photo)



Move mouse to establish area boundaries and click the left mouse button (See photo)

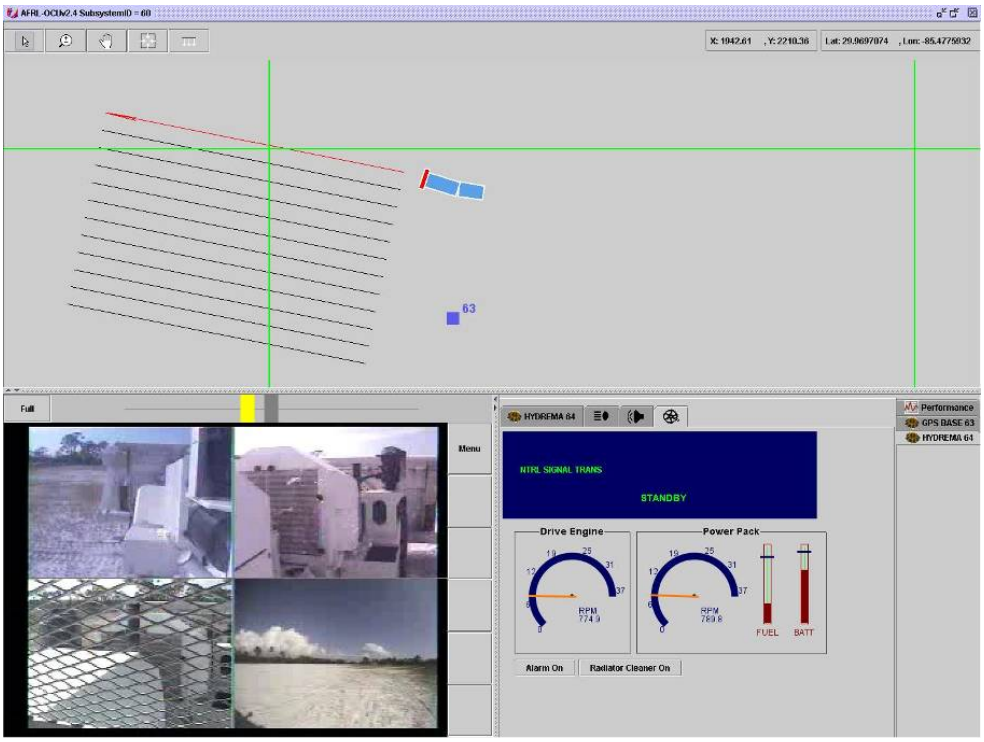


Enter track width (recommend 2.75) See photo

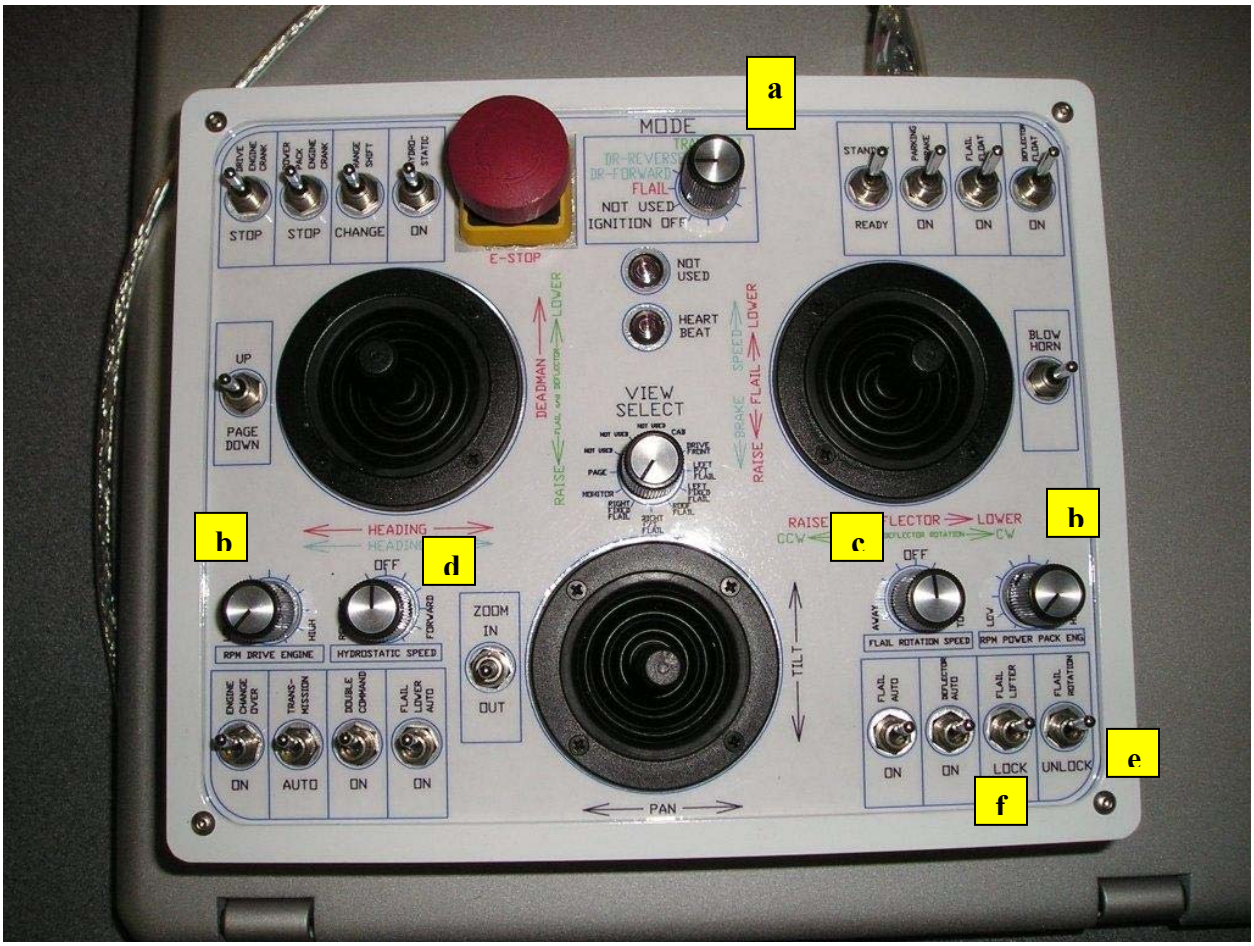


Position vehicle at lane entrance

Note: First lane should appear in red (See photo)

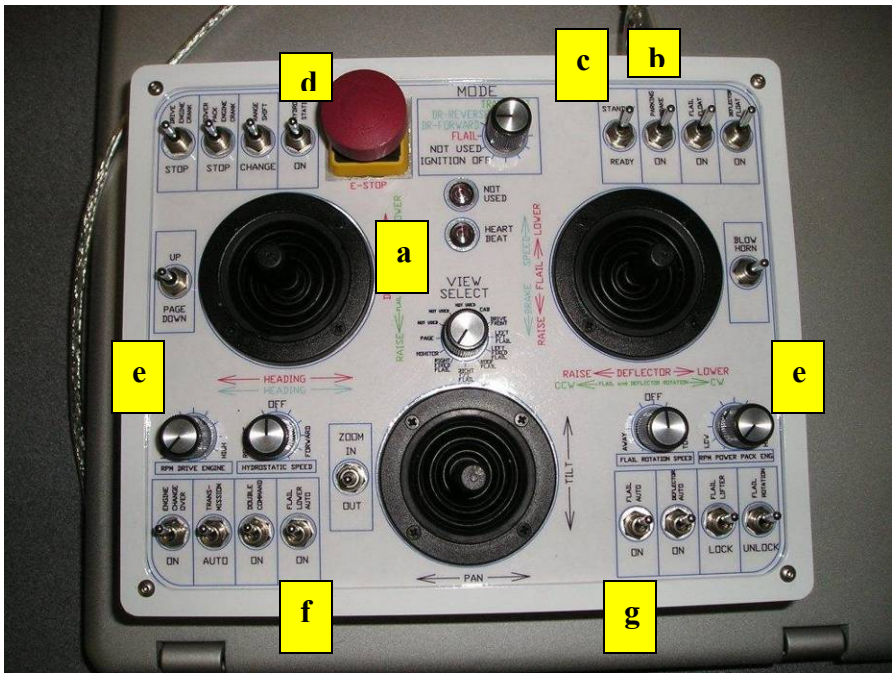


2. **ENGAGING FLAIL SYSTEM**



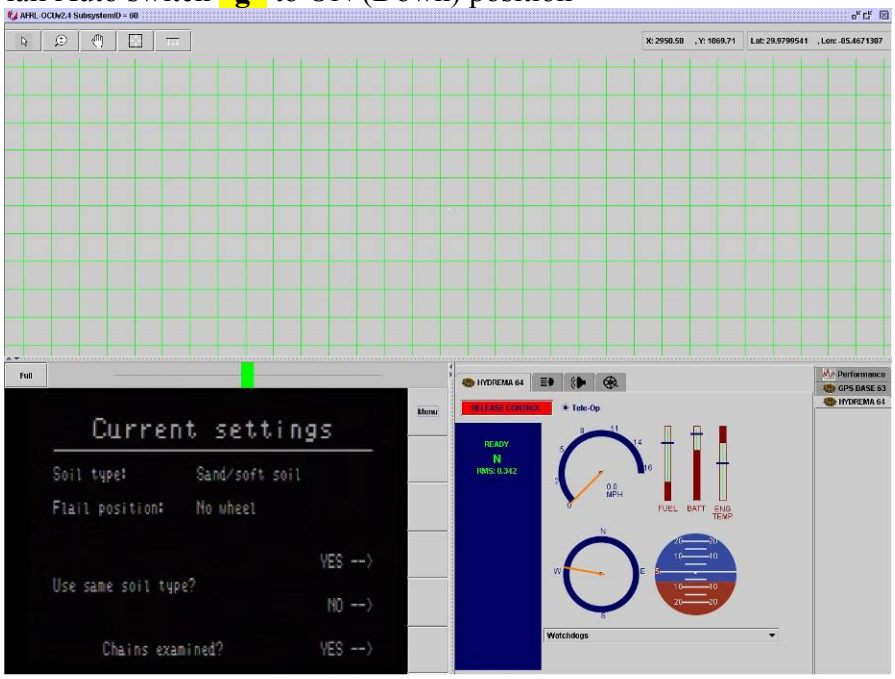
Steps:

Activate MODE Switch **"a"** to FLAIL position
Check Drive Engine & Power Pack Engine RPM knobs **"b"** (both) are set to LOW position
Check Flail Rotation Speed Knob **"c"** OFF position
Check Hydrostatic Speed Knob **"d"** OFF position
Check Flail Rotation switch **"e"** is in LOCK (UP) position
Check Flail Lifter switch **"f"** is in UNLOCKED (UP) position
All other bottom row switches in the Inactive (UP) position

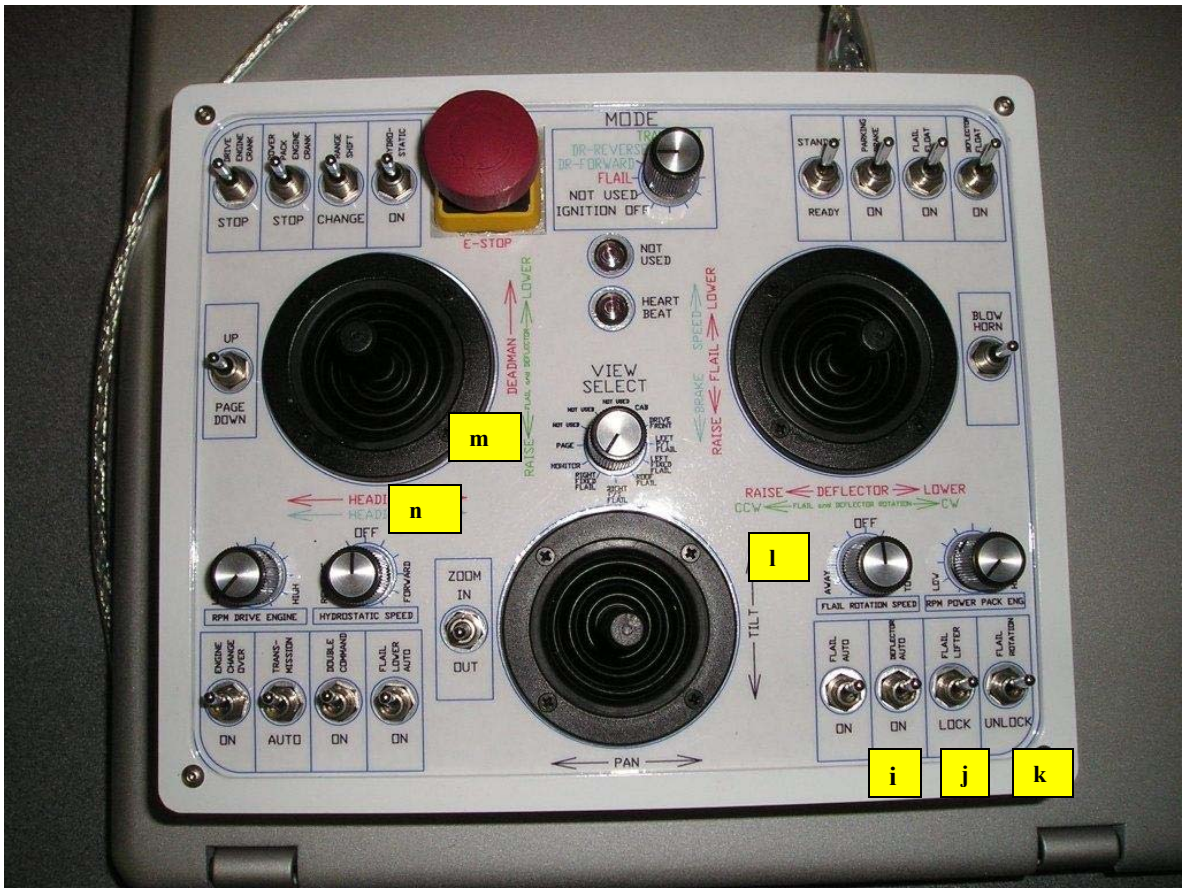


3. **Flail Starting Procedures**:

Select Monitor on VIEW SELECT Knob **"a"**
Parking Brake switch **"b"** is in OFF (UP) position
Activate STANDBY-READY Switch **"c"** to READY position (down)
Activate Hydrostatic Switch **"d"** momentarily to ON (Down) position
Adjust Drive Engine switch **"e"** to 2200 RPM; Adjust Power Pack Engine **"e"** to 2200 RPM
Activate Flail Lower Auto switch **"f"** to ON (Down) position
Activate Flail Auto switch **"g"** to ON (Down) position

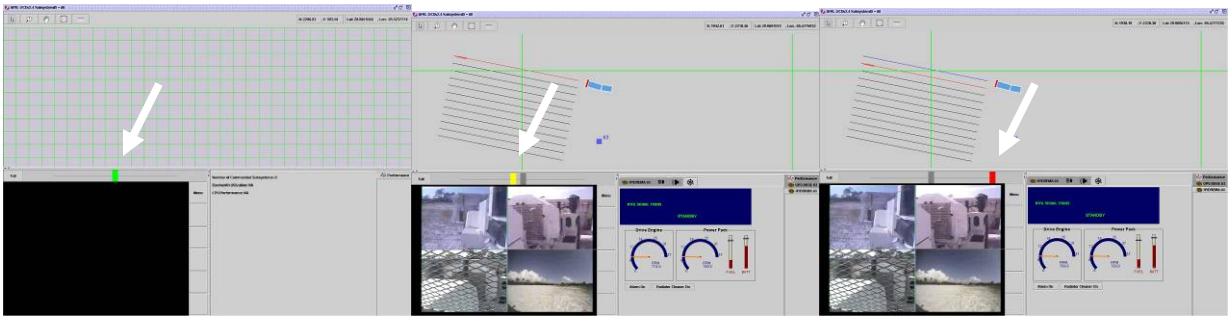


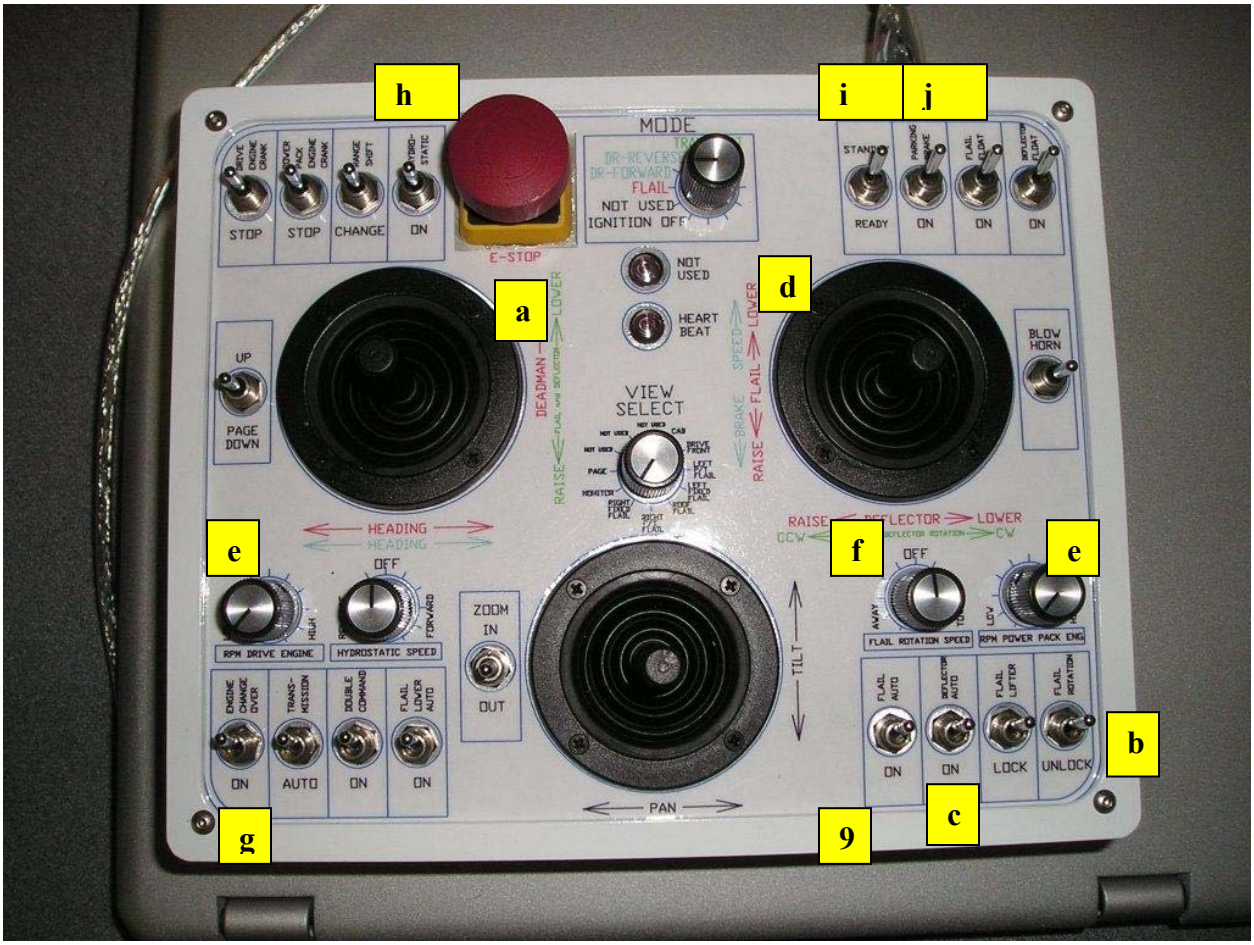
Select Soil Type on MACV OCS Monitor



Activate Deflector Auto Switch **"i"** to ON (Down) position
Activate Flail Lifter Switch **"j"** to LOCK (Down) position
Activate Flail Rotation Switch **"k"** to UNLOCK (Down) position
Slowly adjust Flail Rotation Speed Knob **"l"** to monitor setting
Use left joystick **"m"** to commence forward motion while adjusting Hydrostatic Speed Knob **"n"** to Monitor displayed speed. This is also the left & right steering joystick. The left joy stick is a "deadman", meaning that when released the vehicle will stop.

Note: To ensure the vehicle stays on the selected track pay close attention to the heading track indicator on the OCS. It will remain green when the heading is correct; the indicator will turn yellow as the heading is deviated until it turns red when the heading is completely off track. (See three pictures below)



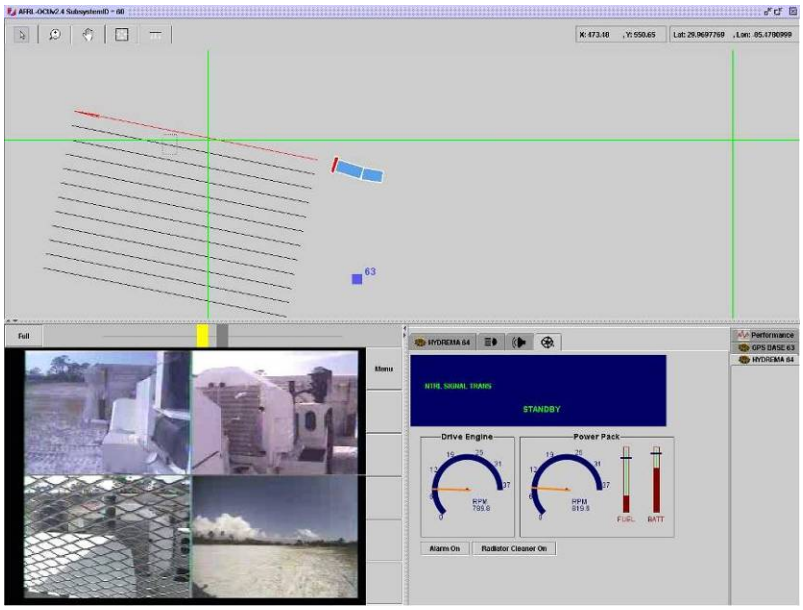


4. **At end of cleared path**

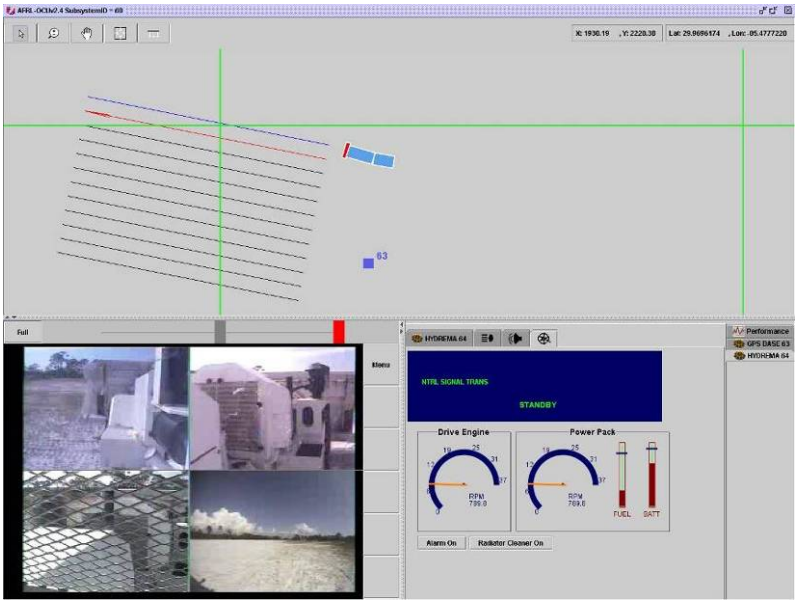
Maintain forward left joystick position **"a"**
Turn Flail Auto Switch **"b"** to OFF (Up) position
Turn Deflector Auto Switch **"c"** to OFF (Up) position
Raise Flail using right joystick **"d"** until no longer in contact with ground
Place left joystick **"a"** in neutral (center) position – this stops vehicle
Reduce RPM on Power Pack and Engine Drive **"e"** Verify on laptop monitor
Wait until flail revolutions are under 200 rpm
Slowly activate Flail Rotation Speed Knob **"f"** to OFF position
Place all bottom row switches **"g"** OFF (Up) position **(NOTE: Raise shield and deflector so as not to drag on return pass.)**
Activate Hydrostatic Switch **"h"** momentarily to OFF (Up) position
Activate STANDBY-READY Switch **"i"** to STANDBY position (UP)
Activate Parking Brake switch **"j"** to ON position (DOWN) position

5. **REPOSITION VEHICLE FOR THE NEXT ROW TO BE CLEARED**

Follow Reverse Drive procedures to traverse cleared lane
Position vehicle at entrance to next row to be cleared
Click the Selection Tool (arrow) button in the top left corner of the OCS display
Position the mouse between the last row and the current row
Press and hold the left mouse button
Drag the mouse to form a small box over the current row (see photo)



The current row turns red and cleared rows turn blue (see photo)



Repeat Engage Flail Operations for each lane

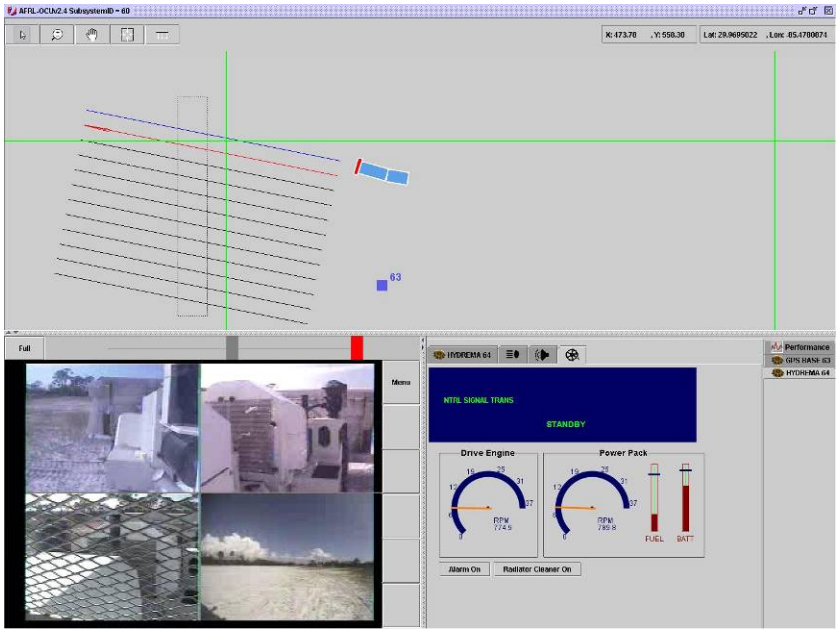
NOTE: Hydrostat Speed should be set from previous passes.

DELETING A DEFINED AREA

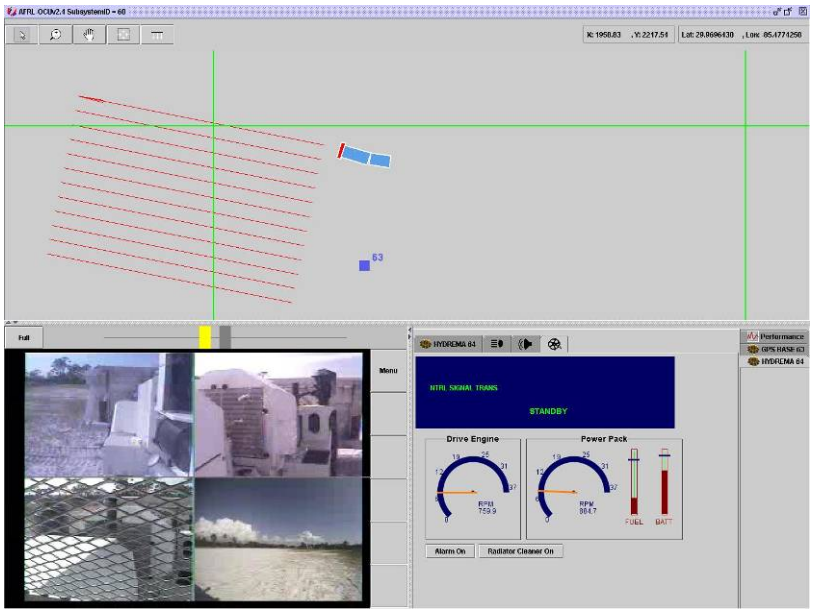
Note: Defining a new area will automatically delete the existing one.

Steps:

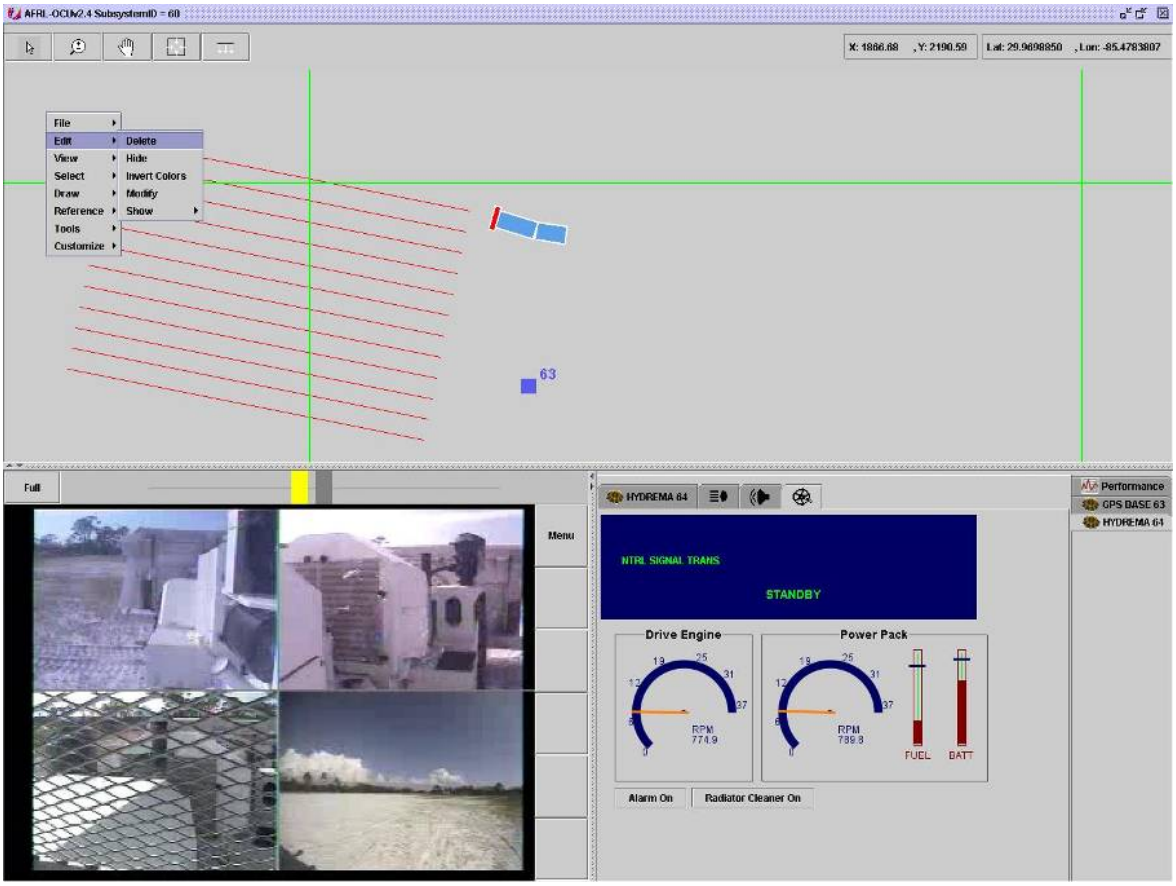
Click the Selection Tool (arrow) button in the top left corner of the OCS display
Position the mouse over the map
Press and hold the left mouse button
Drag the mouse to form a rectangular bounding box covering all rows (see photo)



All rows turn red (see photo)



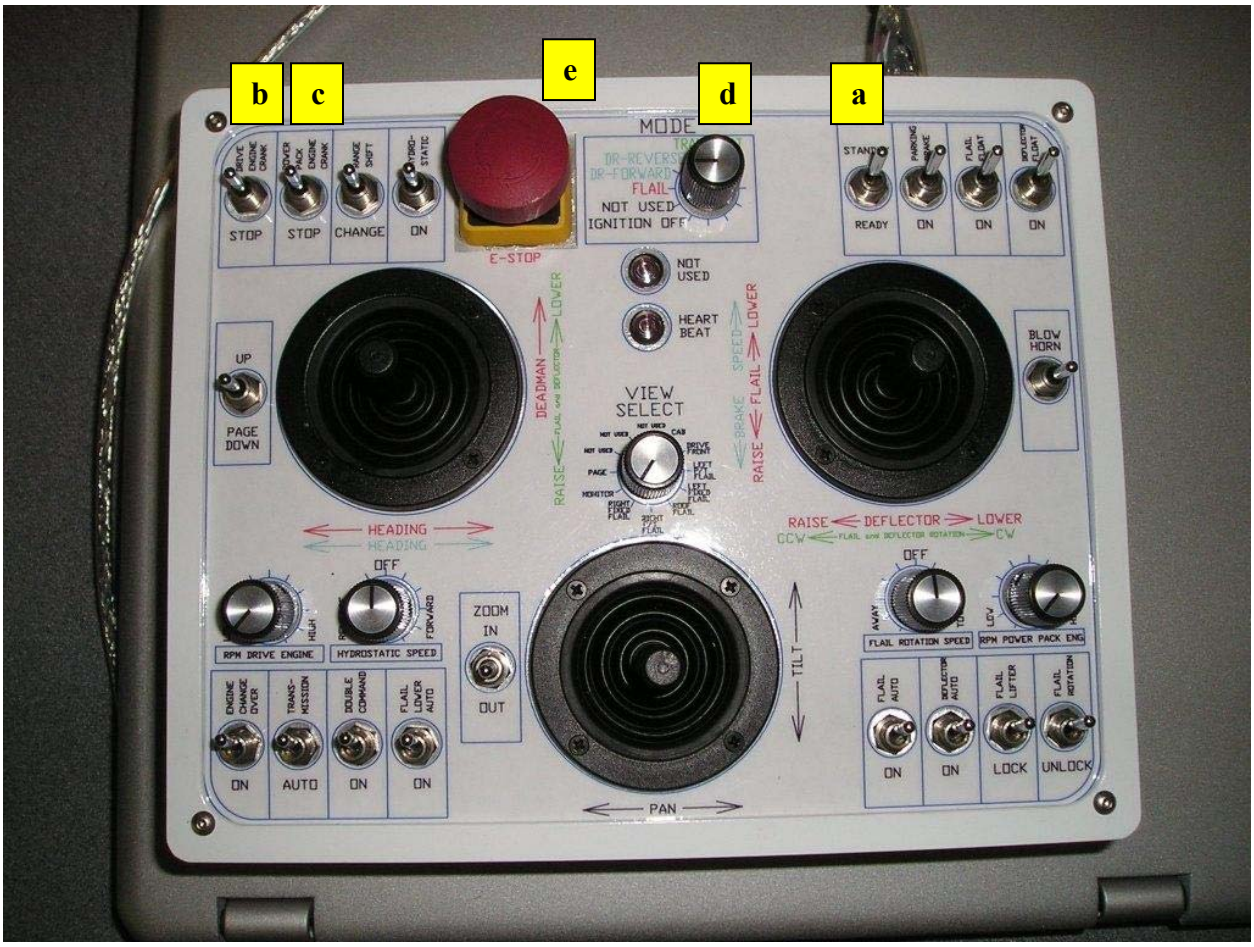
Right click on the map
Select Edit/Delete (see photo)



Section 4

Remote Vehicle Shut Down Procedures

1. **Return to Manual Operation**
Maneuver the vehicle to a safe position using OCS controls
Steps:
Activate SAFE Joystick procedures by:



Place the STANDBY-READY **"a"** switch in STANDBY.
Momentarily put Drive Engine Crank switch **"b"** to STOP. This stops the drive engine.
Momentarily put Power Pack Engine Crank switch **"c"** to *STOP*. This stops the power pack engine.
Put MODE switch **"d"** to IGNITION OFF . Turning the ignition off prevents further battery drain caused by the A/C running when the engines are turned off.
Activate (push-in) E-Stop button **"e".**

2. **Proceed to vehicle**

3. **At Bumper Console**
   Place the Safe – Enable Switch to the Safe position
   Place the Manual – Remote Switch to the Manual position
   Place the Safe – Enable Switch to the Enable position

4. **OCS Shut Down Procedure**
Steps:
   On Laptop click on Release Control Bar – bar turns green
   On Laptop – Click on X upper right corner of monitor
   On Laptop – Click on Start Menu lower left corner of monitor
   Click on Shut Down
   Turn Power OFF on COM/GPS Case

Vehicle is now ready for manual operations.

Section 5

Brake and Throttle Calibration Procedures

Brake Actuator/Controller Replacement and Calibration

Brake Actuator Replacement

1. Remove cover by unscrewing four (4) Allen head screws.

2. Remove cotter pin from clevis pin and remove clevis pin

3. Remove actuator by:
   Removing two socket head cap screws ¼-20

Disconnecting one electrical connector under floor mat

4. Remove clevis and jam nut. Note orientation of slot, be careful not to rotate shaft relative to the actuator body

5. Install clevis and jam nut on new actuator, back jam nut off 3/16” from shoulder of actuator rod
6. Install new actuator, reverse of removal
7. Install clevis pin and cotter pin
8. Replace cover
9. Calibrate if necessary (see section on calibration)

Brake Controller Replacement

1. Remove cover (bottom section on left bulk head when seat is facing aft)

2. Remove controller by:
   Unscrewing four Phillips head screws
   Disconnecting three electrical connectors
3. Install new controller (reverse of remove)
4. Calibrate (see section on brake calibration below)
5. Replace cover

Brake Calibration

1. Preset controller pots (see diagram on controller for 15 turn pots)
   Rotate pot #1 Clock Wise (full extent) 15 times then back off 9 turns
   Rotate pot #2 Counter Clock Wise (full retract) 15 times then back off 6 turns
   Rotate pot #3 Clock Wise (maximum sensitivity) 15 times then back off 5 turns
2. Setup the Hydrema for operation. Refer back to Section 1
3. Place in Drive mode
   Note: At no time during calibration should the engine(s) be running.
4. Activate Enable on the bumper
5. Activate Standby on joystick (This will fully extend the actuator)
6. Adjust pot #1 (extend) on the controller such that the brake pedal is fully out (off)
   Hint: Turn the pot CW (increasing out) until the amber extend light E just stays on when you stop rotating the pot, then back off (CCW) until the light just stays off.
7. Activate Ready on OCU (brake will go to 60%)
8. Activate Double Command
9. With the joystick full back (maximum braking) adjust pot #2 (retract) on the controller such that the brake is fully depressed.

Hint: While holding the joystick full back (full braking) rotate the retract pot #2 CCW until the amber retract light R just stays on when you stop rotating the pot, then back off (CW) until you hear the actuator shaft make a small jumping sound.

10. Verification Check :

When the brake is off (Standby) the extend light E is off and the brake pedal is fully out.

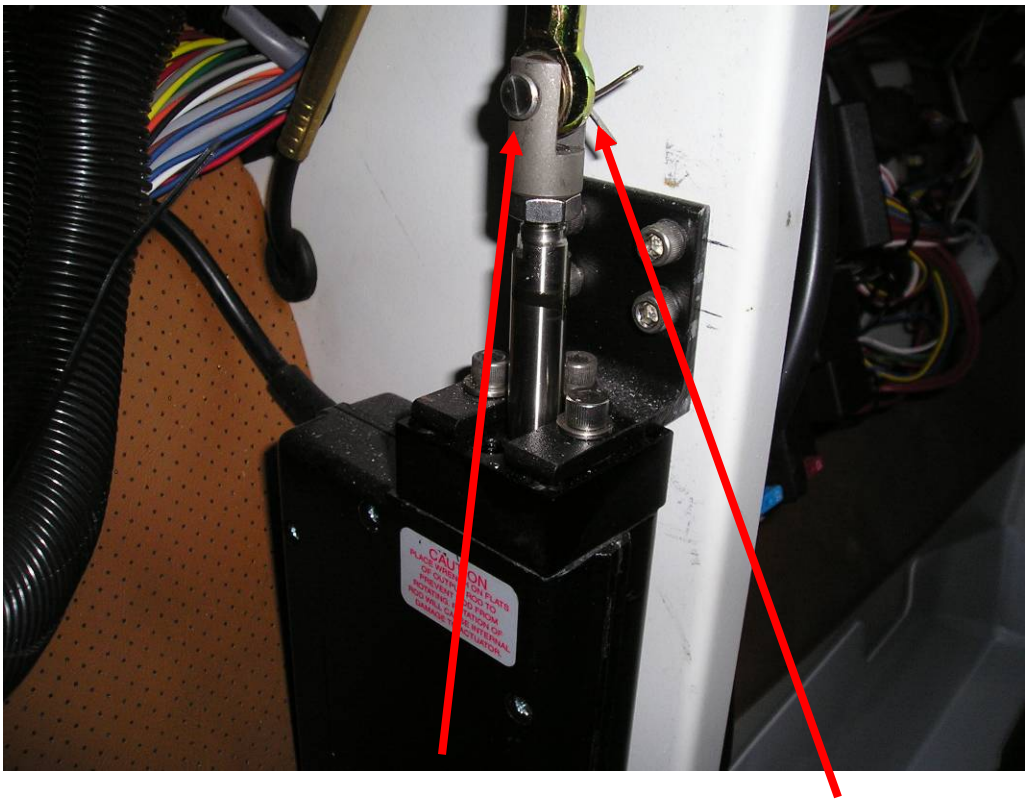
When the brake is full on (Ready, Double Command, brake joystick full back) the retract light R is off and the brake pedal is fully depressed.

THROTTLE ACTUATOR REMOVAL, REPLACEMENT & CALIBRATION PROCEDURES

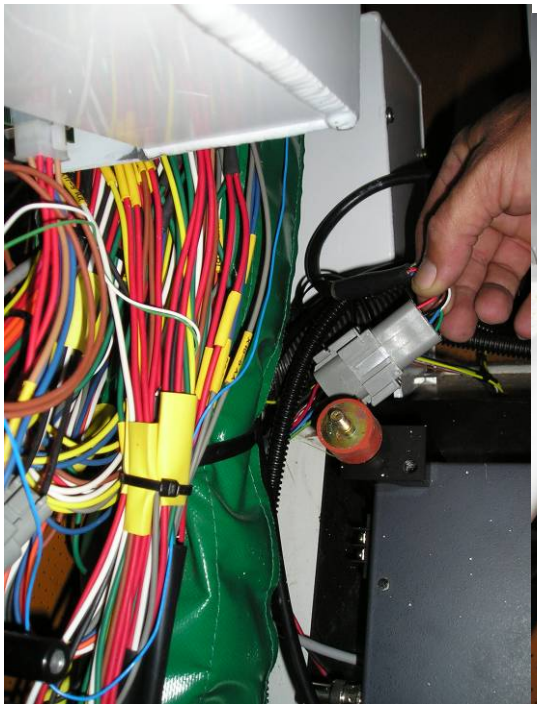
Throttle actuator/controller replacement and calibration

Actuator Replacement

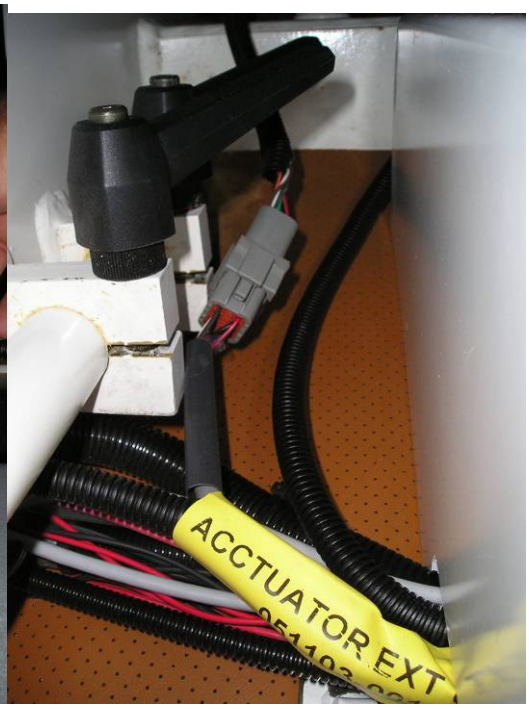
1. Remove Throttle actuator and video stack covers by removing the four (4) 3/16” Allen head screws and the four (4) 7/16” self locking nuts from each cover, respectively. The purpose for removing the video stack cover is to allow ease of access to the throttle actuator electrical connector. This only applies to left throttle actuator. If removing the right throttle actuator cover the same four (4) 3/16” Allen head screws are removed.



2. Remove clevis pin by removing cotter pin and pushing clevis pin through clevis.
3. Remove actuator by:
   Unscrewing the three socket head cap screws ¼-20



Left Throttle Actuator Connector



Right Throttle Actuator Connector

Disconnect one electrical connector

4. Remove clevis and jam nut. Note orientation of slot, be careful not to rotate shaft relative to the actuator body
5. Install clevis and jam nut on new actuator, back jam nut off 3/16" from shoulder of actuator rod
6. Install new actuator (reverse of remove)
7. Install clevis pin
8. Replace cover
9. Calibrate if necessary (see section on calibration)

Throttle Controller Replacement (Refer back to section on Brake Replacement for pictures.)

1. Remove cover (bottom section on right wall)
2. Remove controller
   Unscrew four Phillips head screws
   Disconnect three electrical connectors
3. Install new controller, reverse of remove
4. Calibrate (see section on calibration)
5. Replace cover

Throttle Calibration (Refer back to section on Brake Replacement for pictures.)

1. Preset controller pots (see diagram on controller for 15 turn pots)
   Rotate pot #1 Clock Wise (full extent) 15 time then back off 9 turns
   Rotate pot #2 Counter Clock Wise (full retract) 15 times then back off 6 turns
   Rotate pot #3 Clock Wise (maximum sensitivity) 15 times then back off 5 turns
2. Setup the Hydrema for operation

3. Place in Flail mode
   Note: At no time during calibration should the engine(s) be running.
4. Activate Enable at the bumper
5. Activate Ready on joystick
6. On the joystick set RPM maximum (full CW)
   7. Adjust pot #1 (extend) on the controller such that the manual throttle handle is full RPM when the joystick is set at full RPM
   Hint: Turn the pot CW (increasing RPM) until the amber extend light E just stays on when you stop rotating the pot, then back off (CCW) until the manual handle makes a small jumping move.
8. On the joystick set RPM minimum (full CCW)
9. Adjust pot #2 (retract) on the controller such that the manual throttle handle is minimum RPM when the joystick is set at minimum RPM
   Hint: Turn the pot CCW (decrease RPM) until the amber retract light R just stays on when you stop rotating the pot, then back off (CW) until the manual handle makes a small jumping move.
10. Verification check:
    When the joystick is set to maximum RPM the extend light E is off and the manual throttle handle is at maximum.
    When the joystick is set to minimum RPM the retract light R is off and the manual throttle handle is at minimum.

Section 6

AFRL Model A Joystick Test Document

Joystick Testing

1. Start computer, and then plug Joystick into one of the USB ports. At this point the "HEART BEAT" LED should be blinking on the joystick.

2. Click on "Joystick Test Icon" on Desktop, this will start the Joystick program.

3. Once the Program opens (Fig. 1), Wait for the program to find the proper port, this is indicated by the Red LED with the Text "Searching" next to it, once the program has found the port this LED will turn Green with the Text "Lock" next to it. You will also have Data streaming in the "DATA FROM JOYSTICK' box.

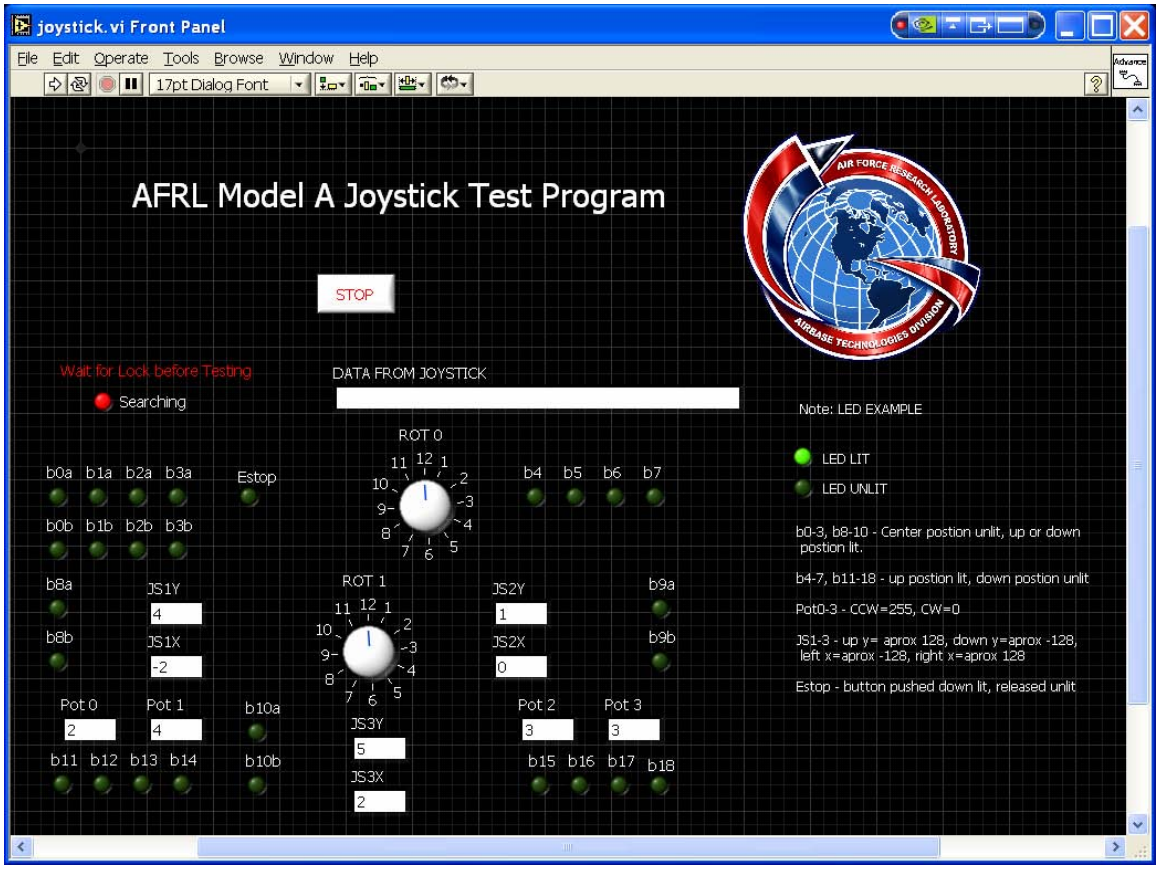


Fig. 1

4. Begin testing the switches and pots, by flipping or turning each of the switches or pots through each position verify each position by referring to indication on computer screen. Pots will have a value of CW 0 to CCW 255. Joysticks will have a value of Up= aprox

128, Down=aprox -128, Left=aprox -128, Right=approx 128. Switches b0-3, b8-10 will be lit in the up and down position and unlit in the center position. Switches b4-b7, b11-b18 will be lit in the up position and unlit in the down position. Estop will be lit in the pushed down position and unlit when released. Rotary switches will show a position of 1 to 12.

5. Once testing is done click on the Stop button. This will properly close the program.

NOTE: Only click on the X in the upper right corner to close the program if clicking the Stop button does not work.

Section 7

Trouble Shooting

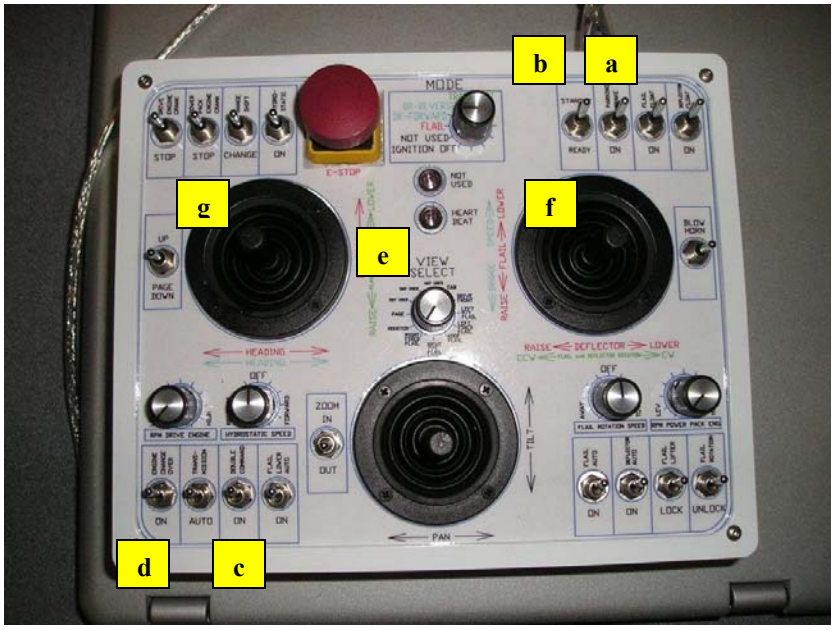
If MACV will not range shift check to see if shift selector in cab is in #1 position range shift will not operate if in any other gear

If computer will not boot up check battery voltage, if below 24vdc unit will shut down and may need to be jump started

Recovery of MACV with one engine

NOTE: This is only to be used when there is only one functional engine.

This is accomplished by using the Engine Change Over switch to allow the operator to do all functions with just one engine such as drive, raise flail and raise flail assembly to the stowed position. To use this function operate the MACV normally except to engage Engine Change Over switch (see photo below) on the joystick box.



Steps:

Activate Parking Brake switch **"a"** to the OFF (Up) position.
Activate STANDBY-READY Switch **"b"** to READY
Activate Double Command switch **"c"** to ON position
Activate Engine Change Over **"d"** switch to the ON position. **(NOTE: There will be no steering if this is not activated)**
Select camera facing direction of travel using the View Select Switch **"e"**
Use right joystick **"f"** as throttle – vehicle moves forward

Use left joystick **"g"** to steer Right and Left
Vehicle stops when right joystick "f" is released to neutral. **(NOTE: Pulling back activates harder braking)**
When stopped:
Turn the Double Command switch "**c**" OFF
Activate STANDBY-READY Switch "**b**" to STANDBY position.
Activate the Parking Brake switch "**a**" to the ON position (UP)

If a problem arises not covered in this Operator Guide, notify AFRL/RXQF, Robotics Research Team at DSN 523-3725, commercial (850) 283-3725 or email Marshall Dutton; marshall.dutton.ctr@tyndall.af.mil.

Section 8

MACV Deployment Container Inventory (Robotic Kit Spares)

Hard Copy in Notebook – Adobe Acrobat Files included on CD-ROM in Notebook

Section 9

Hydrema Spare Parts Inventory (Blue Shipping Container)

Hard Copy in Notebook – Adobe Acrobat Files included on CD-ROM in Notebook

Section 10

MACV Remote Control Wiring Diagrams

Hard Copy in Notebook – Adobe Acrobat Files included on CD-ROM in Notebook